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For Editorial Contents see centre page.

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THE MANUFACTURE AND MANIPULATION OF SEAMLESS TUBES: MESSRS. ACCLES AND POLLOCK, LIMITED.—III.*

IT was the hypodermic syringe which first required the production of tubes of very small diameter. Early hypodermic tubes were of carbon steel, since it was necessary for them to be heat-treated. There were two major difficulties to be faced in making such tubes in the past, namely, inconsistency in temper, which resulted from more than one cause, and the fact that the heat treatment produced scale on both the bore and the outside. Scale could be removed from the outside by polishing, but obviously no such treatment was possible for the bore, the finish of which was of vital importance from a medical point of view. Austenitic stainless steel offered a suitable alternative for hypodermic-needle production, since it could be work-hardened, thus avoiding scaling; and it was possible to obtain tubes which were bright and free from surface blemishes, ready for drawing down to the very small sizes required. In the early 1930's, the "Hypo" department was started at the Oldbury works of Accles and Pollock, Limited, to develop a range of tubes for making hypodermic needles, and this type of tube is still a very important item in that department.

The successful production of a tube of very small bore for making hypodermic needles led to the development of other uses for small tubes, and to the production of a wide variety of precision tubes, both larger and smaller than the hypodermic type. It is of interest to note that new tube sizes have been developed experimentally when there was no known use for them, and that, once the practicability of producing the tube was proved, a market was found for it. To-day, the range of tubes made by the Hypo department is very wide, and the materials include mild, carbon and alloy steels, austenitic and martensitic stainless steels, and numerous non-ferrous metals and alloys. The size range in normal production is from about $\frac{1}{2}$ in. internal diameter down to the smallest tube at present made, which is 0·0017 in. outside diameter, and has a bore of 0·0005 in. This tube, incidentally, was one which was made as an experiment, but a use has been found for it in medical and chemical research. Even this size is not regarded as the smallest possible, though at present it represents the limit of small-tube manufacture at Oldbury.

Within the size and the range of material specifications mentioned, there is a considerable variety of tubes in normal production. In the ordinary round-tube group, the two extremes are represented by the tube with very thin walls, such as is used for making thermostat bellows or instrument pointers, and the thick-walled tube used for gases under high pressure. Thin-walled tubes are made, as normal practice, with the wall as little as 0·001 in. thick. In all these types of tube it is essential that the tube wall shall be free from cracks or flaws of any kind. Fig. 1, herewith, which is a photo-micrograph reduced in the half-tone block to 37 diameters, shows a plain carbon-steel tube 0·095 in. outside diameter and 0·010 in. inside diameter and illustrates the accuracy and finish of the bore, as well as its concentricity and freedom from flaws. The production of such a tube is only possible as a result of extreme care in processing, and strict metallurgical control.

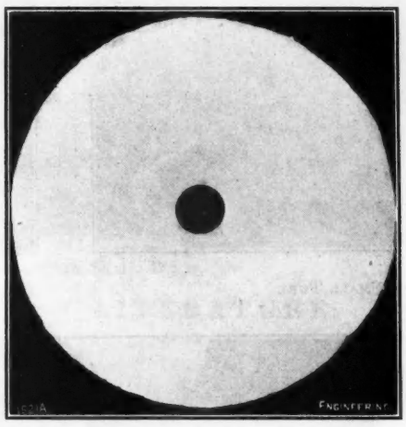


FIG. 1. THICK-WALLED TUBE. × 37.

All the tubes so far mentioned are of plain round form, with a single bore, but the range includes a variety of flattened tubes, for Bourdon-gauge manufacture and similar applications, and multi-bore tubes. Bourdon tubes for high-pressure work are usually supplied round, and a portion of the tube is flattened by the gauge manufacturers after the ends have been prepared for fitting to the instrument. For low pressures, the tubes are supplied drawn to an oval shape, or flattened to leave a gap in the bore, which may be as little as 0·002 in.

One other type of tube made in the Hypo department must be mentioned, namely, the composite tube. For certain purposes, a tube may be needed which possesses qualities not present in any one metal, or it may be that the expense of making the complete tube of a particular metal would not be warranted in the particular circumstances. Examples of tubes made to meet these various requirements include composite tubes of copper and silver, copper and mild steel, and stainless steel and mild steel. The composite tube is made by "sinking" a tube of one metal on to a tube of another, and it may have a bore of expensive metal with the main body of the tube of a cheaper material, or vice versa. The two components of a composite tube may be of equal thickness, or they may be different; for example, to suit certain specified chemical conditions, the body of the tube may be of mild steel of the requisite physical strength, while the inside consists of a thin liner of stainless steel.

The production of tubes of very small diameter is similar in many ways to that of the larger sizes already described, but, particularly as the tubes approach the final drawing stage, differences in plant and technique become apparent The raw material of the Hypo department consists of tubes $\frac{1}{2}$ in. to $\frac{3}{4}$ in. outside diameter, of the appropriate material specification, which are produced by other departments of the Oldbury works. The first stage in drawing is to reduce the diameter on a draw bench of orthodox pattern, as shown in Fig. 2. Orthodox mandrel drawing is practised down to an internal diameter of $\frac{1}{4}$ in.; below this size it is impracticable, and a modification of the process, known as coring, is used. Coring has something in common with mandrel drawing, with one essential difference. A mandrel is of hardened steel, and the reduction of the tube takes place between the mandrel and the die. A core is of softer material, and is reduced in diameter, together with the tube, during the drawing pass. Coring enables the tube to be drawn with the bore supported down to very small inside diameters, the actual internal diameter which can be supported in this way depending upon the length of the tube. Below the minimum size that can be cored, only sinking is possible.

In the first stages of reduction in the Hypo department, tube drawing proceeds as already described in referring to other sections of the works. The mandrel is inserted, the tube end threaded through the die and dogged, and the tube is drawn. Fig. 3, on page 226, indicates the amount of reduction

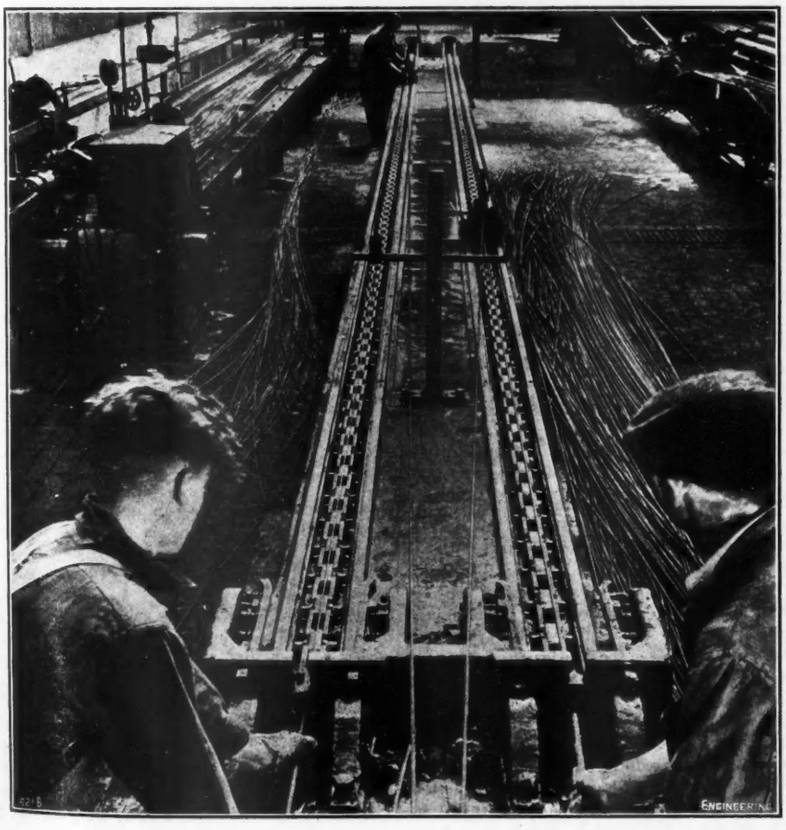


FIG. 2. TWIN DRAW-BENCH FOR SMALL TUBES.

* Part I appeared on page 161, *ante*, and Part II on page 193, *ante*.

THE MANIPULATION OF SEAMLESS TUBES.

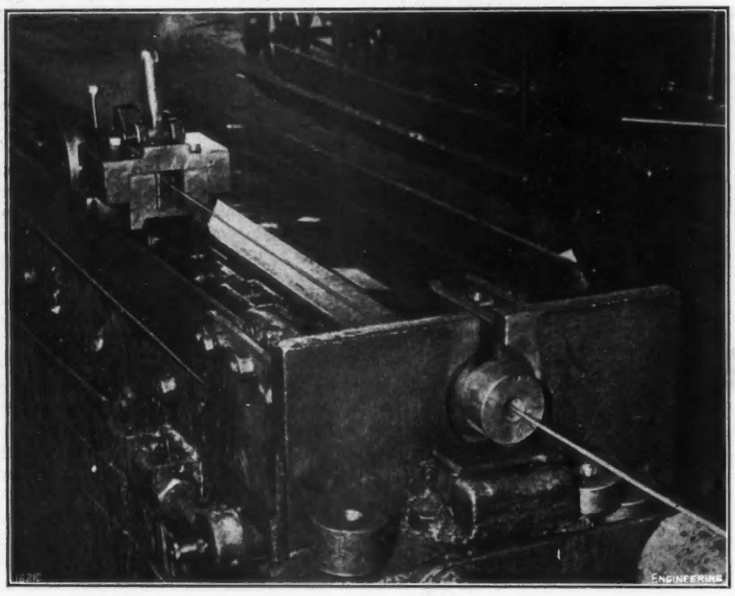


Fig. 3. Mandrel-Drawing Small Tube.

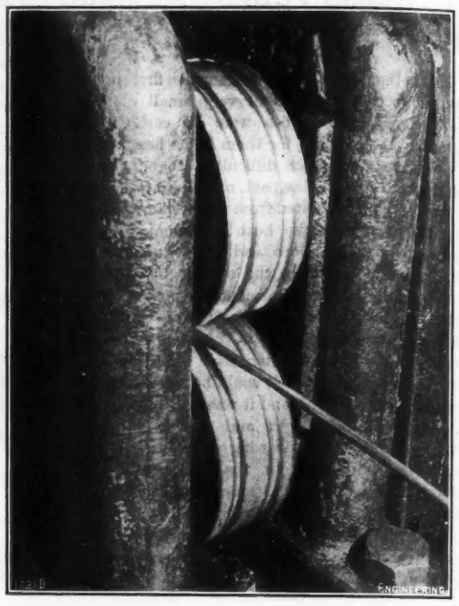


Fig. 4. Rolling to Expand Tube off Mandrel.

per pass at this stage. Even in the early stages, however, there is a difference in practice, especially when drawing the more expensive materials such as stainless steel. Normal methods of tagging, which produce a short length of scrap material at the end of a tube, are not used. Instead, the end of the tube is formed into a short cone by rotary swaging, and the end of the mandrel is shaped to fit the cone. This makes a considerable reduction in the amount of material which has to be cut off as scrap. After drawing, the mandrel has to be removed, and this is done either by the process of reeling, as previously described, or by passing the tube between small grooved rollers, as shown in Fig. 4, herewith, which have the same effect. Annealing after each pass is the rule except where work-hardening is required. Inert-atmosphere furnaces are used for annealing and are of orthodox pattern, except that special means are adopted to pass the tubes through them. In the case of the very small tubes produced by the Hypo department, the normal roller conveyors or wire-mesh conveyors used in furnaces are not suitable. Instead, the furnace has a flat bed, and the tubes are drawn through it in bundles, attached to a heat-resisting wire by means of one or two turns of lashing wire. The traction wire is drawn through the furnace continuously by a power-driven reel, and the operators lash the small bundles to it as it is travelling; precisely the method used in warships of Nelson's day when weighing anchor, the anchor cable being "nipped" by temporary lashings to another cable, the "messenger," which was drawn aft along the deck by the capstan. A gas curtain is provided at the entry end of the furnace, and a sand seal at the exit.

When the tubes have been reduced as far as possible by mandrel drawing, a core of softer material (steel or brass) is inserted, and the process continues; still, for the present, on a draw bench of normal pattern. After each pass, the tube is annealed, which softens the core and removes any work-hardening effect from it. A length of core is left projecting from each end of the tube, and, after annealing, the two ends are gripped and the core is stretched. This causes some reduction of area of the core, and finally, of course, breaks it. The two ends of the core are then withdrawn, leaving the bore of the tube clear. Coring is possible down to an internal diameter of 0·012 in., but only in short lengths. In this diameter, about 4 ft. is the maximum length which can be cored; if the tube were longer, there would be a danger of the core breaking before the diameter had been reduced sufficiently for the whole of it to be withdrawn. As the inside diameter of the tube increases, however, so the length of core which can be removed by stretching also increases, and, in diameters of about 0·03 in., tubes can be cored up to about 50 or 60 ft. long.

As the tubes are reduced in size, so the amount of reduction per pass falls, as would be expected, but it remains proportional. A tube 0·010 in. outside diameter, for example, would be reduced 0·001 in. in one pass, which is the equivalent of a ½-in. reduction on a tube 1 in. in diameter. In the very small sizes, drawing is done on machines somewhat similar to those used for wire, and tagging is performed by small rotary swaging machines, as shown in Fig. 5, herewith. The drawing machine, which is illustrated in Fig. 6, opposite, is of simple design, consisting of a drum with a small dog for holding the end of the tube, and a die-mounting plate. The drum is carried on one end of a motor-car type of axle, with a differential, and the drive is continuous from an electric motor mounted underneath the bench. At the other end of the axle is a brake, the application of which by a foot pedal sets the drum in motion. The die holder, shown in Fig. 7, on page 240, is capable of holding up to three diamond dies, and the operator can thus draw the tube up to three

Fig. 5. Tagging Small Tube on Rotary Swaging Machine.

MANIPULATION OF SEAMLESS TUBES.

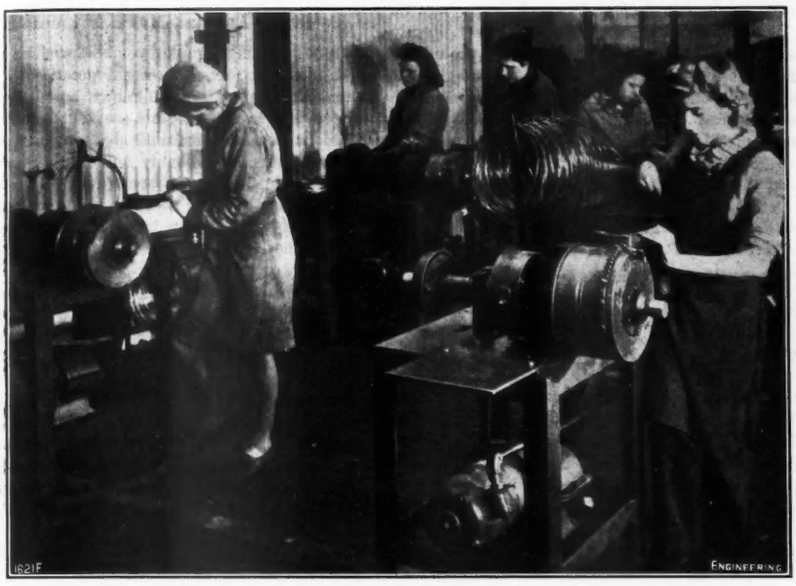


FIG. 6. DRAWING MACHINES FOR SMALL TUBES.

times on the same machine. At this stage in the drawing, when the tubes are approaching their finished condition, work-hardening is usually in progress, so that the inter-pass annealing is omitted. The operator therefore tags the tube in the rotary swaging machine, inserts the tube end into the die, draws the tube, removes the coil from the drum, and immediately repeats the process.

In the very small sizes, where visual inspection of the bore is impossible, nitrogen is blown through the tube to expel any foreign matter, and to ascertain that the bore is continuous. Nitrogen is used because it is an inert gas, and also because it is readily obtainable in dry form. These two qualities ensure that there is no oxidation of the bore when the test gas is blown through it. Towards the final drawing passes, nitrogen is blown through between each pass. When the tube has been reduced to the finished size, it is straightened. In the case of the larger tubes in the range, this is done by hand and eye. The operator rolls the tube through staggered rollers to perform the initial straightening, and examines the tube through the bore by sighting it against the light. Any final setting necessary is done by inserting the tube in two fixed baize-lined jaws, and bending it by hand. Straightening of the very small sizes is done by machine, as shown in Fig. 8, on page 240. This machine has a revolving head, with toggle-mounted jaws which are closed on to the tube to induce reverse bending. The head is then revolved at high speed, while the operator pushes the tube through the jaws by hand.

Finally, the tubes are inspected. To ensure that the bore is clear and that the walls are sound, nitrogen is blown through the tubes while they are immersed in oil or water. Bubbles of gas at the open end of a tube indicate that the bore is clear, while bubbles in any other position would show a fracture in the wall. The inspection concludes with an examination of the outside of the tubes, which is done by a combination of sight and touch, each tube being passed individually between the operator's finger and thumb (Fig. 9, page 240). Slight flats or other surface imperfections are immediately detected by feel, the operators soon developing a high degree of skill. Microscopic and microphotographic methods of examination are available for use when necessary.

LITERATURE.

Photometry.

By DR. JOHN W. T. WALSH. Constable and Company, Limited, 10 and 12, Orange-street, London, W.C.2. [Price 63*s.*]

SINCE the first edition of this book was published in 1926, considerable progress has been made in the technique of light measurement and much greater use is now made of photo-electric methods. To deal adequately with these and maintain the authoritative character of the work has necessitated the rewriting of more than two-thirds of the original text. An introductory historical note outlines the chief contributions to the development of photometry from its origin in Pierre Bouguer's essay of 1729 to the present day, and indicates lines along which future advances are to be expected. The main properties of radiation are then summarised, particular attention being paid to those aspects of direct application in photometry. Since "the eye remains and must remain the ultimate judge of light, both qualitatively and quantitatively," it is fitting that a thorough discussion of the eye and vision should be given. A useful chapter on photo-electric cells deals with the properties of photo-emissive cells of the vacuum, gas-filled and photo-multiplier types, and of photovoltaic cells, together with their associated circuits and the errors to which they are liable.

Photometry may be defined as "the measurement of light by visual comparison or by some method which gives the same result as such a visual comparison," and, in the chapter on "The Principles of Photometry," the latest internationally agreed definitions of the various photometric quantities are stated and their relations to one another derived. Details concerning the specification and realisation of the primary standard of luminous intensity and of the secondary working standards that serve as temporary custodians of the unit fixed by the primary standard are followed by two important chapters devoted, respectively, to the measurement of luminous intensity and to light distribution and total flux measurement. Contained in them are illustrated descriptions of, and operating instructions for, photometers based on the inverse-square law, polarisation and Talbot's law, together with a comprehensive account of the use of the integrating sphere. The next three chapters deal, in turn, with the difficult but practically important problem of heterochromatic photometry and various types of flicker photometer, with colorimetry and colorimeters, from the point of view of photometric measurement, and with spectrophotometry and standard forms of spectrophotometer.

Following these are two chapters on illumination and luminance and on the measurement of reflection, transmission and absorption factors. Illumination photometers, or illuminometers, are usually portable instruments, and the special precautions needed in using them are fully described. Other matters of interest are the sections on microphotometry and on the transmission of optical systems. The special problems presented by the photometry of projection apparatus, including allowance for atmospheric absorption, are explained in Chapter XIV. Following this, there is a brief account of stellar photometry, in which the photocell has played so prominent a part. The final chapter, which describes the equipment of a small photometric laboratory, is full of invaluable practical advice. It is not alone in this respect, however, for the book abounds in hints on such points as the importance of screening and comfortable conditions for observing, which, to the inexperienced, may seem trivial, but which contribute so materially towards accurate photometric measurements.

An attempt has been made, in the references at the ends of the chapters, to include all papers published since 1925 while retaining only the more important earlier references from the first edition. The appendixes contain a list of books on photometry, symbols and definitions of photometric quantities, and a number of numerical tables. Dr. Walsh's long association with the National Physical Laboratory has given him a wealth of experience of all aspects of photometry and every type of photometer, and the essence of this experience is set out with admirable clarity in this standard work on the subject.

Trusts and Foundations.

Compiled by GUY W. KEELING, B.A., and edited by THOMAS LANDAU, A.L.A. Bowes and Bowes, 1 and 2, Trinity-street, Cambridge. [Price 42*s.* net.]

As a rule, we do not review works of reference under the heading of "Literature," but this volume, described in the sub-title as "A Select Guide to Organisations and Grant-making Bodies Operating in Great Britain and the Commonwealth," deserves a rather more extended notice than is practicable in the space devoted to "Annuals and Reference Books." As the Rt. Hon. Lord Nathan, who was chairman of the Committee on the Law and Practice relating to Charitable Trusts, observes in a foreword, "It is odd that . . . no one, not even the Charity Commissioners, can say with any precision how many charitable trusts exist in England and Wales." The figure of known trusts given to the committee, he adds, was 110,000, "but it was generally agreed that the actual number is greater than that."

The present work, which has been compiled with the aid of the Association of Special Libraries and Information Bureaux (Aslib) and eight other organisations, lists only about 1,000 trusts and foundations—less than 1 per cent. of the total mentioned by Lord Nathan; and if we point out a few omissions it is not done in any spirit of carping criticism, but because they are of particular interest to engineers—a not unimportant section of the community, after all—and because Mr. Keeling's preface invites suggestions "whereby subsequent editions may be enlarged by the addition of further Trusts and Foundations of significance." We are somewhat surprised, for instance, to see that no mention is made of the Clayton Fellowships and

other substantial awards in the gift of the Institution of Mechanical Engineers, the many valuable scholarships awarded by the Institution of Naval Architects, or, apparently, of the Sir Robert Blair travelling scholarships of the London County Council. More recently instituted are the annual Maudslay Scholarship of 150*l.*, awarded jointly to young engineers by the Maudslay Society and the Junior Institution of Engineers, the capital sum for which is held by the Charity Commissioners; and the Thomas Lowe Gray prizes of the Royal Society of Arts and the Institute of Marine Engineers. No doubt there are many others, directly concerning engineers, which might have been included, but are not; and we would suggest, therefore, that the compilers of this admirable book might well canvass the engineering societies more thoroughly before proceeding with the publication of the next edition.

La Mécanique Ondulatoire.

By THÉODORE KAHAN and BERNARD KWAL. Collection Armand Colin No. 268. Librairie Armand Colin, 103, Boulevard Saint-Michel, Paris (5e). [Price 260 francs.]

IN a notable volume, published in 1940 in this series, Dr. Kahan revealed his mastery of an important branch of nuclear physics by producing one of the best introductions to radioactivity and atomic transmutation. The present volume, written in conjunction with the late Bernard Kwal, is equally remarkable, providing what is, in effect, a veritable miniature treatise on wave mechanics. By way of introduction, a brief résumé is given of the basic notions of the restricted theory of relativity, of Hamilton's principle and the function and equation of Jacobi, which are fundamental in quantum as well as in classical mechanics. It was Louis de Broglie's realisation that the evidence that light waves may behave as particles implied that material particles might likewise exhibit wave properties which led Schrödinger to the formulation of his wave mechanics. After explaining de Broglie's method of determining the wavelength associated with a moving particle, and describing its experimental verification, a discussion of the dynamics of the de Broglie waves leads to the derivation of Schrödinger's wave equation and its solution, together with Born's interpretation of the wave function. The distinction between the concept of "state" in classical physics and in quantum mechanics is stressed, as well as the role of the principle of spectral decomposition in quantum physics.

The more abstract alternative approach based on the calculus of matrices, introduced by Heisenberg and elaborated by Born and Jordan, is considered next. A summary of the essentials of matrix algebra is provided, and the equivalence of wave and matrix mechanics established. An illuminating chapter on the principle of uncertainty is followed by applications of wave mechanics to the passage of material waves through potential barriers and to the hydrogen atom. In many cases, exact solutions of the wave-mechanical equations are unobtainable, so that recourse must be had to methods of approximation, three of which are considered in some detail, together with methods for dealing with problems in which the perturbation is a function of time.

Chapter VII is devoted to systems involving several corpuscles and to the theory of the hydrogen molecule. The relativistic generalisation of the wave equation, the Dirac theory of electron spin, and his theoretical prediction of the Positron lead the reader into deeper waters, as likewise do the method of superquantification and the quantum theory of the electromagnetic field, which form the subject of the concluding chapter. On the last line of page 1, $\beta z c$ should read $\frac{\beta z}{c}$, and here and there letters or numbers have dropped out, mostly from the subscripts or superscripts. It is customary, and preferable, to refer to a component vibration having a frequency double that of the fundamental as the second, not the first, harmonic, as on page 45.

Wave mechanics is a difficult subject, partly because of the specialised mathematical procedures employed and partly on account of the insight required to obtain a physical interpretation of the mathematical symbolism. Not the least of the merits of this admirably compact, yet comprehensive, exposition is that the authors have squarely faced these difficulties instead of shirking them.

The Science of Petroleum, Vol. V, Part II. Synthetic Products of Petroleum.

Edited by DR. B. T. BROOKS and DR. A. E. DUNSTAN. Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-square, London, E.C.4. [Price 100s. net.]

ON page 259 of our issue of February 27, 1953, in reviewing the book, *The World's Oilfields: The Eastern Hemisphere* which is Part I of Vol. V of *The Science of Petroleum*, we mentioned that further parts of Vol. VI of this most comprehensive series were in preparation, and also Part III of Vol. V. No mention was made of Part II of Vol. V, as it was already in the press; but it is now available and should be of particular interest at the present time, when petroleum is challenging coal as the possible source of many chemicals of increasing industrial importance. The book is divided into two main sections, dealing, respectively, with "Synthetic Products" and "Refinery Processes," each of these being again divided into chapters which are, in effect, separate monographs by experts in the several fields.

The section on synthetic products is, perhaps, reading for the industrial chemist rather than for the engineer, though, admittedly, it is becoming increasingly difficult to define their respective spheres and interests where the practice of chemical engineering is concerned. The subjects dealt with include the polymerisation of hydrocarbons, the catalytic polymerisation of olefines, the polymers and co-polymers of isobutylene, chemicals for synthetic rubbers, the manufacture of organic chemicals from the hydrocarbons of petroleum and natural gas, the nitro-alkanes, carbon black (the production of which, we note, was described by Vitruvino), and surface active agents derived from petroleum. This section, however, occupies less than a third of the book, the other two-thirds being devoted to "Refinery Processes," which are subdivided into distillation, refinery processes such as methods of solvent extraction and the de-waxing of lubricating oils, metallurgical aspects of refinery steels, and the engineering problems associated with pressure vessels and low-temperature equipment; cracking, and the main catalytic processes by which it is accomplished; hydrogenation and dehydrogenation; and alkylation, with particular reference to sulphuric acid, hydrocarbons, and paraffins. There is an index of subjects, and another of names. It is really unnecessary to add that the production is of a high standard, as with the rest of the series. Each chapter has its own bibliography, and several of them are truly voluminous in extent; so much so, in fact, as to leave a doubt whether the authors might not have been a little more selective in the choice of references, bearing in mind that few readers will be in a position to consult the whole range, and that many of the papers cited also contain bibliographies. Effective referencing means much more than merely compiling a list; most readers also require guidance.

COAL PRODUCTION IN 1953.—Saleable coal mined during the 30 weeks ended August 1, 1953, amounted to 128,412,400 tons, compared with 130,202,400 tons obtained during the corresponding 30 weeks of last year, a decline of 1,790,000 tons. Of this year's production, 121,622,900 tons were deep-mined coal and 6,789,500 tons opencast coal.

DESIGN AID FOR SHRINK-FIT CALCULATIONS.

By SIMON ARCHER, M.Sc., M.I.Mech.E.

WHEN designing shrunk assemblies such as built-up crankshafts, etc., it is usual practice to base the calculations on the well-known Lamé formulæ and provided interference fits are kept below, say, 0·0016 in. per inch (for mild steel on mild steel), this assumption is probably sufficiently justified. Above this figure there is some evidence to show that local yielding may occur at the inner bore of the hub, resulting in a reduced grip as compared with the theoretical value predicted by the Lamé formula.

There are, of course, two considerations which have to be satisfied when designing a shrunk assembly, namely, (1) the proposed grip force, or torque at the estimated slipping point, must be not less than a certain minimum value, based on experience, necessary to give a sufficient factor of safety against slip in service; and (2) the interference fit necessary to achieve the proposed grip force, or torque, must not induce greater hoop stresses than a certain maximum value at the bore of the hub having the proposed dimensions, this value again being based on experience.

Since, in many cases, the loading on a shrunk assembly is mainly of the torsional type as, for example, in crankshaft service, the following notes will relate to torsionally-loaded assemblies only, although the necessary modifications for axial loading will readily be seen.

Grip-Torque Calculations.—It is assumed that the allowable maximum shaft stress is given and that the maximum torque to be transmitted through the shrunk connection is also known, resulting in a certain basic minimum diameter of shaft, say d_0. Associated with this basic shaft size, it is usual to express the dimensions of the hub, namely, axial length, h_0, and radial, or eyehole, thickness, t_0, in terms of d_0. Thus, $h_0 = a\,d_0$, and $t_0 = b\,d_0$, where a, b may be constants. These dimensions being given, then the required minimum interference fit, $\Delta_{0(\text{min.})}$, to give the appropriate factor of safety against slip when transmitting the maximum torque proposed, can readily be derived using the Lamé relation,

$$p = \mathrm{E}\,\Delta_{0(\text{min.})}\left(\frac{k^2-1}{2\,k^2}\right),$$

in conjunction with the basic shaft and hub dimensions and assumed coefficient of friction, μ, at slip, where

$$k = \text{ratio}\left(\frac{\text{hub dia.}}{\text{shaft dia.}}\right) = 1 + \frac{2\,t_0}{d_0}$$

$\Delta_{0(\text{min.})}$ = minimum interference fit required (in. per in.).

E = Young's modulus (lb. per square inch), and

p = grip stress at shrinkage surface (lb. per square inch).

In practice it may often be found desirable to depart slightly from the basic shaft and hub dimensions and to use a different shrinkage interference fit. It is then convenient to have a ready means of comparison to ensure that the proposed grip torque is at least equal to that of the basic shrunk assembly.

The basic grip torque at slip can be expressed as

$$\mathrm{T}_0 = \mathrm{E}\,\Delta_{0(\text{min.})} \times \tfrac{1}{2} \times \frac{4\,\frac{t_0}{d_0}\left(1+\frac{t_0}{d_0}\right)}{\left(1+2\,\frac{t_0}{d_0}\right)^2} \times \pi\,d_0\,h_0\,\mu \times \frac{d_0}{2}$$

$$= \pi\,\mathrm{E}\,\mu\,\Delta_{0(\text{min.})} \times \frac{a\,b\,(1+b)}{(1+2\,b)^2} \times d_0^3.$$

DESIGN AID FOR SHRINK-FIT CALCULATIONS.

Fig. 1(a). GRIP.

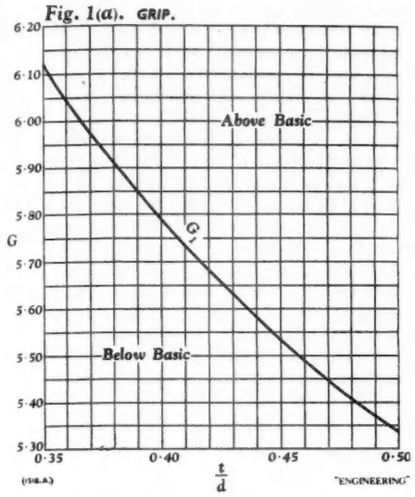
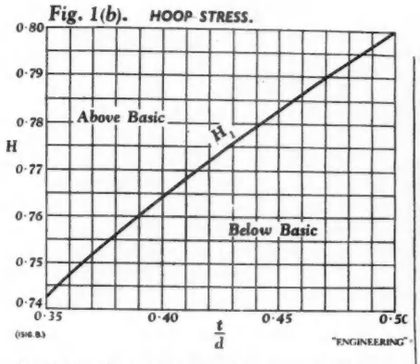


Fig. 1(b). HOOP STRESS.



Similarly, the proposed grip torque at slip can be written,

$$T = E\,\Delta \times \tfrac{1}{2} \times \frac{4\frac{t}{d}\left(1+\frac{t}{d}\right)}{\left(1+2\frac{t}{d}\right)^2} \times \pi\, d\, h\, \mu \times \frac{d}{2}$$

$$= \pi\, E\, \mu\ \Delta \times \frac{\frac{t}{d}\left(1+\frac{t}{d}\right)}{\left(1+2\frac{t}{d}\right)^2} \times h\, d^2.$$

Equating to basic slipping torque,

$$\Delta\, h\, d^2 \times \frac{\frac{t}{d}\left(1+\frac{t}{d}\right)}{\left(1+2\frac{t}{d}\right)^2} \not< \Delta_{0(\min.)} \times d_0^2 \times \frac{a\,b\,(1+b)}{(1+2\,b)^2},$$

or since

$$\frac{a\,b\,(1+b)}{(1+2\,b)^2} \text{ is known} = (\text{say})\ \frac{1}{A}.$$

Therefore

$$G = \frac{\Delta}{\Delta_{0(\min.)}} \times \frac{h\,d^2}{d_0^2} \times A \geqslant G_1$$

where

$$G_1 = \frac{\left(1+2\frac{t}{d}\right)^2}{\frac{t}{d}\left(1+\frac{t}{d}\right)}.$$

G_1 can be calculated once and for all as a function of $\frac{t}{d}$ as shown plotted in Fig. 1 (*a*) for a range of values of $\frac{t}{d}$ suitable for crankshaft or other design. All that is then necessary is to evaluate the quantity G, appropriate to the proposed shrunk assembly and by reference to the graph it is at once evident whether the proposed grip torque is above or below the basic requirements defined by the curve of G_1.

Hoop-Stress Calculations.—In a similar way the proposed maximum hoop stress at the bore of the hub may be compared with the maximum value for the basic assembly. Let the maximum value of the basic interference fit which will just not exceed the maximum permissible hoop stress f_0 at the bore of the basic hub be denoted by $\Delta_{0(\max.)}$.

Then,

$$f_0 = E\,\Delta_{0(\max.)} \times \frac{k^2+1}{2\,k^2}$$

$$= E\,\Delta_{0(\max.)} \times \tfrac{1}{2} \times \left[\frac{1+\left(1+2\frac{t_0}{d_0}\right)^2}{\left(1+2\frac{t_0}{d_0}\right)^2}\right]$$

$$= E\,\Delta_{0(\max.)} \times \tfrac{1}{2} \times \left[\frac{1+(1+2\,b)^2}{(1+2\,b)^2}\right].$$

In the proposed assembly,

$$f = E\,\Delta \times \tfrac{1}{2}\left[\frac{1+\left(1+\frac{2\,t}{d}\right)^2}{\left(1+\frac{2\,t}{d}\right)^2}\right].$$

Therefore, equating to basic maximum hoop stress,

$$\Delta \times \left[\frac{1+\left(1+\frac{2\,t}{d}\right)^2}{\left(1+\frac{2\,t}{d}\right)^2}\right] \leqslant \Delta_{0(\max.)} \times \left[\frac{1+(1+2\,b)^2}{(1+2\,b)^2}\right],$$

and since $\frac{(1+2\,b)^2}{1+(1+2\,b)^2}$ is known = (say) B,

therefore,

$$H = B \times \frac{\Delta}{\Delta_{0(\max.)}} \leqslant H_1,$$

where

$$H_1 = \frac{\left(1+\frac{2\,t}{d}\right)^2}{1+\left(1+\frac{2\,t}{d}\right)^2}.$$

Again, H_1 can be evaluated once and for all as a function of $\frac{t}{d}$ and this has been plotted in Fig. 1 (*b*) for a suitable range of values of $\frac{t}{d}$. It is then only necessary to calculate the quantity H for the proposed assembly and compare with the limiting graph for H_1. Values of Δ are shown in Table I.

Fig. 2. REDUCTION OF EFFECTIVE INTERFERENCE FIT DUE TO HOLLOW BORING OF SHAFT.

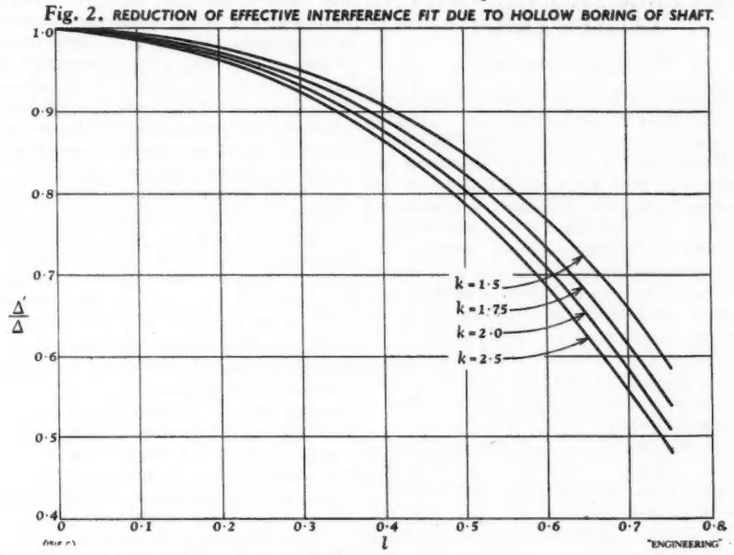


TABLE I.—*Values of* Δ.

Thousands of an Inch per Inch Diameter.	Fraction of Diameter.	Decimal Equivalent.
1·0	$\frac{1}{1000}$	0·0010
1·1	$\frac{1}{909}$	0·0011
1·2	$\frac{1}{833}$	0·0012
1·3	$\frac{1}{769}$	0·0013
1·4	$\frac{1}{714}$	0·0014
1·43	$\frac{1}{700}$	0·00143
1·5	$\frac{1}{667}$	0·0015
1·6	$\frac{1}{625}$	0·0016
1·7	$\frac{1}{588}$	0·0017
1·8	$\frac{1}{556}$	0·0018
1·82	$\frac{1}{550}$	0·00182
1·9	$\frac{1}{526}$	0·0019
2·0	$\frac{1}{500}$	0·0020

Influence of Shaft Bore on Effective Interference Fit.—Let Δ be the interference fit in the actual assembly having shaft diameter d and hollow bore of diameter d_1 and let Δ^1 be the equivalent interference fit in a solid shaft assembly, of equal shaft and hub diameters, necessary to give the same limiting grip torque and maximum hub hoop stress.

Then, from Lamé's equations, it can be shown that

$$\left(\frac{k^2 \pm 1}{k^2}\right)\Delta^1 = \left[\frac{(k^2 \pm 1)\,(1-l^2)}{k^2-l^2}\right]\Delta$$

or

$$\frac{\Delta^1}{\Delta} = \frac{1-l^2}{1-\frac{l^2}{k^2}}, \text{ where } l = \frac{d_1}{d}.$$

Values of $\frac{\Delta^1}{\Delta}$ are plotted in Fig. 2 against the shaft : bore ratio, l, for a number of values of the hub : shaft ratio, k. It will be seen that the reduction in interference fit does not greatly exceed 10 per cent. until the bore is larger than about 40 per cent. of the shaft diameter; also that the loss of grip rises with increase in hub : shaft ratio.

Having calculated the effective solid-shaft interference fit, Δ^1, as shown above, this value can be used directly with the graphs Figs. 1 (*a*) and (*b*).

ANALYSIS OF RIGID FRAMES BY AN ELECTRONIC DIGITAL COMPUTER.

By R. K. Livesley.

This article describes work which has been carried out by the author on the electronic digital computer installed at the Computing Laboratory, The University, Manchester. A brief note describing the computer is followed by an account of the method of stress analysis used. The analysis is presented in detail as it is applied to rigid-jointed plane structures with straight uniform members, but methods are also indicated for dealing with various other types of structure. Matrix notation is used throughout, as this enables the analysis to be presented in a compact form; this account of the stress analysis is not concerned with computational methods, although the matrix analysis developed has, in fact, proved well adapted to the requirements of a digital computer.

The method of stress analysis is followed by a general description of the "routines" so far developed for use with the Manchester machine; details of machine operation and coding are not included, but some information is given concerning the capacity of the present routines, together with the times required to analyse certain types of frame. The article is concluded by examples of a rigid portal frame and of a Vierendeel truss analysed on the machine and, finally, an outline is given of plans for future work.

Electronic Computers.

The publicity given to the high-speed electronic digital computers developed since the war has tended to stress their ability to solve problems of extreme complexity. While it is true that these machines may be used to advantage for solving extremely long and difficult problems in mathematical physics, they may also be of use in treating the simpler problems of practical engineering, which merely involve large amounts of tedious calculation. Structural analysis is such a problem. The application of electronic computing to the analysis of plane rigid-jointed steel frameworks will be considered in this paper. Such analysis represents only the first step in the complete process of actual framework design but it is hoped, in due course, to develop additional routines for the complete process to be performed by the machine.

The chief merit of an electronic computer is the speed and accuracy with which it will perform a given "routine" of calculations. The design of the "routine" is a relatively long process, since it involves translating the complete organisation of the calculation into a code which the machine can absorb. The first problem is therefore to decide on the method of structural analysis to be used. Several factors are involved in this choice and it is by no means certain that the method used by a designer, working on the drawing board and with a hand calculating machine, will prove the most suitable for mechanisation.

The main requirement is that the set of routines developed should be applicable to a wide variety of structural problems for it is clearly undesirable to have to design a complete set of routines for each structure to be analysed. For this reason, the method chosen is one first developed by Kron[1] who used it to set up the analogous electric circuits of certain structures; it is independent of any computational schemes and may easily be extended to space frameworks. It presents a logical and exact approach to the analysis of frameworks in general, although it is not particularly well suited to ordinary hand methods of calculation.

[1] References are given on page 233.

Manchester Electronic Computer.

The machine has two forms of storage, known as the magnetic and the electronic stores. In the former, information is retained on the surface of a rotating drum; in the latter, it appears as a pattern of dots on the screen of a cathode-ray tube. The electronic store comprises eight such tubes, each with a capacity of 32 "lines." Each line may be considered as representing a binary number of 40 digits, that is, as a positive integer less than 2^{40}, or, using the most significant digit to indicate the sign, as an integer within the range $\pm 2^{39}$. Alternatively, the line may be treated as a fraction between either 0 and 1, or $\pm\frac{1}{2}$. All arithmetical operations take place in the electronic store. The machine performs these operations on lines under the control of a "routine"—or list of coded instructions—which is itself held in part of the electronic store. Instructions are obeyed at a rate of about 900 per second. Routines not in use, and other information not immediately required, are kept in the magnetic store. Information may be "read" from the magnetic store to the electronic, or "written" from the electronic to the magnetic. The magnetic store is divided into "tracks," of which there are at present 128, the contents of a track corresponding to the information stored in two tubes of the electronic store.

The reading and writing transfers mentioned above operate either between a single tube and a half-track, or between a pair of tubes and a full track. Such transfers are in general part of the routines, and the instruction to perform one appears in a routine in the same way as instructions for the normal arithmetical operations. In a calculation using several routines, for instance, the last instruction in each routine will be one which results in the next routine being brought down from the magnetic stores and entered at the correct point. All routines, and any other information required for a given calculation, are fed into the machine on standard five-hole teleprinter tape, which must be previously punched by hand. The characters punched on the tape are dealt with by a special input routine, which distributes the various sequences of information to their correct locations in the two stores. In a typical calculation, the "programme" of routines is first fed into the machine as described above. The tape, punched with the data of the problem to be solved, is then placed in the tape reader and the machine uses the input routine to absorb the contents. The last few characters on the tape form an instruction to commence the calculation, that is, to bring down and enter the first routine of the programme and, after this, the various routines succeed each other in the correct sequence. The final routine will normally be a printing routine, printing the answers from given locations in the store.

Analysis of Plane Frameworks.

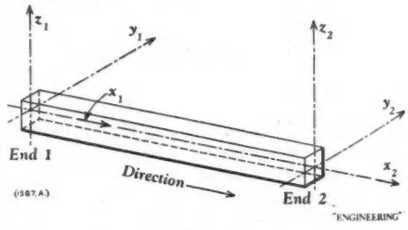
General Assumptions.—Only structures composed of straight uniform members joined at their ends will be considered for the moment and the analysis will be restricted to problems in which the external loading consists of forces and couples applied at the joints. This involves no real loss of generality, since any loading of a member at points between its ends may be replaced by equivalent "fixed-end" forces and moments at the joints themselves, without affecting the stresses in the rest of the framework. When the displacements and stresses due to this equivalent loading have been evaluated, the actual stresses in the loaded member may be found by a simple super-position. All joint displacements and rotations and all stresses are assumed to be linear functions of the applied joint loads. This implies that all displacements and rotations are small compared with the dimensions of the structure.

These assumptions imply that the joint loads and the joint displacements and rotations are connected by a set of linear simultaneous algebraic equations. The analysis to be described provides a means for automatically setting up this set of equations. If these equations can be solved (and an electronic computer is admirably suited to the solution of such sets of equations) the internal stresses in the framework may be immediately calculated.

Notation.—The basic unit is a straight uniform member of length L, cross-sectional area A, and flexural rigidity E I. It is convenient in diagrams to place an arrow on the member to denote a specific direction, which may be chosen arbitrarily, and the two ends are then denoted by suffices 1 and 2. Right-handed orthogonal axes x_1, y_1, z_1 and x_2, y_2, z_2, are set up at each end of the member, the axes being chosen so that x_1, x_2 lie along the member, with y_1, y_2 and z_1, z_2 lying in the directions of the principal axes of the cross-section, as shown in Fig. 1. The displacements and rotations of the two ends are then denoted by single symbols, D_1 and D_2, where

$$D_1 = \begin{bmatrix} x_1 \\ y_1 \\ z_1 \\ \theta_1 \\ \phi_1 \\ \psi_1 \end{bmatrix}, \text{ and } D_2 = \begin{bmatrix} x_2 \\ y_2 \\ z_2 \\ \theta_2 \\ \phi_2 \\ \psi_2 \end{bmatrix};$$

Fig. 1. NOTATION.



rotations are considered positive when clockwise, in the usual way. Similarly, the forces and moments applied at the ends of members are represented by single symbols, F_1 and F_2, where

$$F_1 = \begin{bmatrix} F_{x1} \\ F_{y1} \\ F_{z1} \\ M_{x1} \\ M_{y1} \\ M_{z1} \end{bmatrix}, \text{ and } F_2 = \begin{bmatrix} F_{x2} \\ F_{y2} \\ F_{z2} \\ M_{x2} \\ M_{y2} \\ M_{z2} \end{bmatrix}.$$

In the case of plane frameworks, the column-vectors, D_1, D_2 and F_1, F_2, will have, of course, only three components. In the remainder of this article the terms "displacements" and "loads" will be taken to mean column-vectors of the above type with, in general, six components, or three components in the case of plane frameworks.

When considering a structure formed of connected members, the displacements and loads in the final set of equations will be expressed in a single reference frame x', y', z'. The directions of these axes will be determined by the overall geometry of the structure, and will normally be chosen so that they coincide with the axes of symmetry or other preferred directions when the structure is considered as a whole. Primes will be used to denote such overall "system co-ordinates." Thus, the end displacements, D_1 and D_2, are equivalent to displacements D_1' and D_2' in the general reference frame and the two sets of displacements are connected by an orthogonal transformation matrix T, such that

$$D_1 = T D'_1, \quad D_2 = T D'_2. \qquad (1)$$

Similarly the end loads, F_1 and F_2, are expressed in system co-ordinates by F'_1 and F'_2, where

$$F_1 = T F'_1, \quad F_2 = T F'_2. \qquad (2)$$

When discussing a structure of several members, an additional suffix is required to denote a particular

member. Thus, the displacement of end 1 of the third member is written D_{13}. In order to avoid confusion, square matrices, which already have two suffices, are placed in brackets before the member suffix is attached; that is, $(Y_{12})_3$ is a matrix associated with the third member. It has also been found convenient to number the joints separately. Joint loads and displacements are represented by the symbols ξ and Δ, respectively, these, of course, being measured in the general reference frame (primes are discarded here since there is no possible ambiguity). Thus, if members 1 and 2 meet at joint 3, the end 2 of member 1 being rigidly attached to the end 1 of member 2, the equations of compatibility and equilibrium at the joint will be written

$$\Delta_3 = D'_{21} = D'_{12}, \text{ and}$$
$$\xi_3 = F'_{21} + F'_{12}.$$

Load-Displacement Equations for a Single Member in a Plane.—Using the above notation, the equations connecting the quantities D_1, D_2 and F_1, F_2 now have to be established. Considering displacements and loads in the x, y plane only,

$$D_1 = \begin{bmatrix} x_1 \\ y_1 \\ \psi_1 \end{bmatrix}, D_2 = \begin{bmatrix} x_2 \\ y_2 \\ \psi_2 \end{bmatrix}, F_1 = \begin{bmatrix} F_{x1} \\ F_{y1} \\ M_{z1} \end{bmatrix}, F_2 = \begin{bmatrix} F_{x2} \\ F_{y2} \\ M_{z2} \end{bmatrix}.$$

In order to obtain the equations for a member with arbitrary loads acting at each end (these loads, however, being such as to keep the member in equilibrium), consider the two following cases and then apply the principle of super-position. Clamp end 2 of the member shown in Fig. 1, (i.e. $D_2 = 0$), and then apply a load P_1 to end 1; the simple theory of bending gives

$$P_1 = Y_{11} D_1,$$

where

$$Y_{11} = \begin{bmatrix} \frac{EA}{L} & 0 & 0 \\ 0 & \frac{12EI}{L^3} & \frac{6EI}{L^2} \\ 0 & \frac{6EI}{L^2} & \frac{4EI}{L} \end{bmatrix}.$$

Also, from the conditions of equilibrium,

$$P_2 = \lambda_{21} P_1,$$

where

$$\lambda_{21} = \begin{bmatrix} -1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & L & -1 \end{bmatrix}.$$

Similarly, clamping end 1 ($D_1 = 0$) and applying a load Q_2 to end 2, gives

$$Q_2 = Y_{22} D_2,$$

where

$$Y_{22} = \begin{bmatrix} \frac{EA}{L} & 0 & 0 \\ 0 & \frac{12EI}{L^3} & \frac{-6EI}{L^2} \\ 0 & \frac{-6EI}{L^2} & \frac{4EI}{L} \end{bmatrix},$$

and from the conditions of equilibrium,

$$Q_1 = \lambda_{12} Q_2,$$

where

$$\lambda_{12} = \begin{bmatrix} -1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & -L & -1 \end{bmatrix}.$$

Combination of the two cases gives

$$P_1 + Q_1 = F_1 = P_1 + \lambda_{12} Q_2 = Y_{11} D_1 + \lambda_{12} Y_{22} D_2,$$

and

$$P_2 + Q_2 = F_2 = \lambda_{21} P_1 + Q_2 = \lambda_{21} Y_{11} D_1 + Y_{22} D_2.$$

If Y_{12} and Y_{21} are now defined by the equations

$$Y_{12} = \lambda_{12} Y_{22},$$
$$Y_{21} = \lambda_{21} Y_{11},$$

then,

$$\left.\begin{aligned} F_1 &= Y_{11} D_1 + Y_{12} D_2, \\ F_2 &= Y_{21} D_1 + Y_{22} D_2. \end{aligned}\right\} \quad . \quad (3)$$

These two equations give the end loadings in terms of the end displacements. They cannot be solved for D_1 and D_2, since the matrix formed by the four Y-matrices is singular; this is to be expected, since it is obviously possible to give the member an arbitrary rigid-body displacement.

In order to write down conditions of compatability and equilibrium at the joints, it is necessary to express all end displacements and end loads in the general reference frame of the system. The next step is therefore to determine the form taken by equations (3) in system co-ordinates. If x', y', are the system co-ordinates, as shown in Fig. 2,

Fig. 2. SYSTEM CO-ORDINATES.

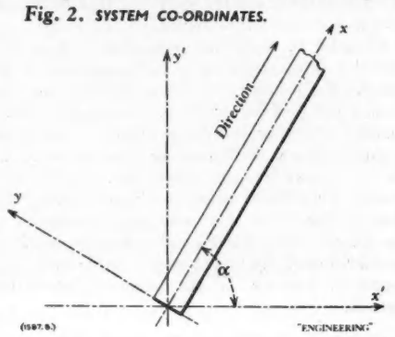


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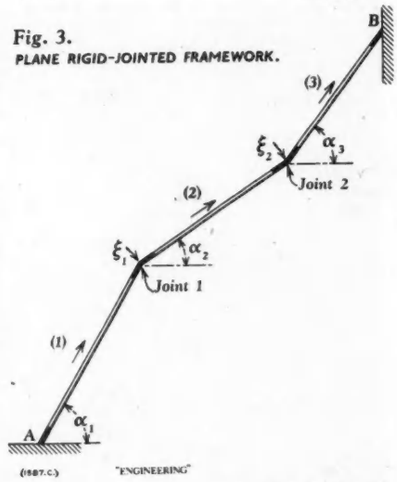
Fig. 3.
PLANE RIGID-JOINTED FRAMEWORK.



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herewith, the orthogonal matrix T takes the simple form

$$T = \begin{bmatrix} \cos\alpha & \sin\alpha & 0 \\ -\sin\alpha & \cos\alpha & 0 \\ 0 & 0 & 1 \end{bmatrix},$$

where α is the inclination of the member to the x'-axis. Hence, substituting from equations (1) and (2), equations (3) become

$$T F'_1 = Y_{11} T D'_1 + Y_{12} T D'_2,$$

and

$$T F'_2 = Y_{21} T D'_1 + Y_{22} T D'_2$$

and, therefore,

$$F'_1 = (T^{-1} Y_{11} T) D'_1 + (T^{-1} Y_{12} T) D'_2,$$
$$F'_2 = (T^{-1} Y_{21} T) D'_1 + (T^{-1} Y_{22} T) D'_2,$$

or, defining Y'_{ij} by the relationship

$$(T^{-1} Y_{ij} T) = Y'_{ij}, (i, j, = 1, 2),$$

we have

$$\left.\begin{aligned} F'_1 &= Y'_{11} D'_1 + Y'_{12} D'_2, \\ F'_2 &= Y'_{21} D'_1 + Y'_{22} D'_2. \end{aligned}\right\} \quad . \quad (4)$$

Analysis of a Plane Rigid-Jointed Framework.—Consider the framework shown in Fig. 3, herewith, acted on by loads ξ_1 and ξ_2, as shown therein. Equations such as equations (4) above can be written down for each member as follows—

$$\left.\begin{aligned} F'_{1i} &= (Y'_{11})_i D'_{1i} + (Y'_{12})_i D'_{2i}, \\ F'_{2i} &= (Y'_{21})_i D'_{1i} + (Y'_{22})_i D'_{2i}, \end{aligned}\right\} \quad (5)$$

where i may denote member 1, 2 or 3.

The conditions of compatibility and equilibrium at the joints are

$$D'_{11} = 0, D'_{12} = D'_{21} = \Delta_1,$$
$$D'_{22} = D'_{13} = \Delta_2, D'_{23} = 0,$$

and

$$F'_{21} + F'_{13} = \xi_1, F'_{22} + F'_{13} = \xi_2.$$

Substituting these expressions in equations (5), and adding two pairs of equations to obtain the external joint loads ξ_1 and ξ_2, gives

$$F'_{11} = (Y'_{12})_1 \Delta_1, \quad . \quad . \quad (6)$$
$$\xi_1 = [(Y'_{22})_1 + (Y'_{11})_2] \Delta_1 + (Y'_{12})_2 \Delta_2, \quad (7)$$
$$\xi_2 = (Y'_{21}) \Delta_1 + [(Y'_{22})_2 + (Y'_{11})_3] \Delta_2, \quad (8)$$
$$F'_{23} = (Y'_{21})_3 \Delta_2. \quad . \quad . \quad (9)$$

The two matrix equations, (7) and (8), form a set of six linear equations for the six degrees of freedom of the system. Moreover, the matrix of the coefficients is now non-singular, and the equations may therefore be solved for Δ_1 and Δ_2. When this

TABLE I.—COEFFICIENTS OF THE Y'-MATRICES.
($s = \sin\alpha$, $c = \cos\alpha$.)

Y'_{11}	$c^2\frac{EA}{L} + s^2\frac{12EI}{L^3}$	$sc\left(\frac{EA}{L} - \frac{12EI}{L^3}\right)$	$-s\frac{6EI}{L^2}$
	$sc\left(\frac{EA}{L} - \frac{12EI}{L^3}\right)$	$s^2\frac{EA}{L} + c^2\frac{12EI}{L^3}$	$c\frac{6EI}{L^2}$
	$-s\frac{6EI}{L^2}$	$c\frac{6EI}{L^2}$	$\frac{4EI}{L}$
Y'_{12}	$-\left(c^2\frac{EA}{L} + s^2\frac{12EI}{L^3}\right)$	$-sc\left(\frac{EA}{L} - \frac{12EI}{L^3}\right)$	$-s\frac{6EI}{L^2}$
	$-sc\left(\frac{EA}{L} - \frac{12EI}{L^3}\right)$	$-\left(s^2\frac{EA}{L} + c^2\frac{12EI}{L^3}\right)$	$c\frac{6EI}{L^2}$
	$s\frac{6EI}{L^2}$	$-c\frac{6EI}{L^2}$	$\frac{2EI}{L}$
Y'_{21}	$-\left(c^2\frac{EA}{L} + s^2\frac{12EI}{L^3}\right)$	$-sc\left(\frac{EA}{L} - \frac{12EI}{L^3}\right)$	$s\frac{6EI}{L^2}$
	$-sc\left(\frac{EA}{L} - \frac{12EI}{L^3}\right)$	$-\left(s^2\frac{EA}{L} + c^2\frac{12EI}{L^3}\right)$	$-c\frac{6EI}{L^2}$
	$-s\frac{6EI}{L^2}$	$c\frac{6EI}{L^2}$	$\frac{2EI}{L}$
Y'_{22}	$c^2\frac{EA}{L} + s^2\frac{12EI}{L^3}$	$sc\left(\frac{EA}{L} - \frac{12EI}{L^3}\right)$	$s\frac{6EI}{L^2}$
	$sc\left(\frac{EA}{L} - \frac{12EI}{L^3}\right)$	$s^2\frac{EA}{L} + c^2\frac{12EI}{L^3}$	$-c\frac{6EI}{L^2}$
	$s\frac{6EI}{L^2}$	$-c\frac{6EI}{L^2}$	$\frac{4EI}{L}$

has been done, equations (6) and (9) give the redundant reactions at A and B, or, alternatively, equations (5) enable all the internal forces to be determined.

Some Practical Details of the Method.—Table I gives the coefficients of the four Y′ matrices for a member inclined at angle α to the x′-axis. In the majority of frameworks, a large proportion of the members will have the simpler matrices associated with the values $\alpha = 0$ deg., $\alpha = 90$ deg.

Referring to equations (4), the matrices Y'_{11}, Y'_{22}, may be described as "direct"-stiffness matrices, relating the load at an end to the displacement thereat, while the matrices Y'_{12}, Y'_{21}, are "cross"-stiffness matrices, relating the load at one end of a member to the displacement at the other. Using these ideas, it is quite easy to build up the set of linear equations (7) and (8) directly from the stiffness matrices, without first writing down the equations (5).

Considering equations (7) and (8), the leading diagonal coefficient matrices in the two equations are found to be the sums of the direct-stiffness matrices of the members meeting at the respective joints. In equation (7), for instance, the term $(Y'_{22})_1 + (Y'_{11})_2$ represents the sum of the direct-stiffness matrices of members 1 and 2. The matrix $(Y'_{22})_1$ appears because member 1 has end 2 at the joint; member 2 has end 1 at the joint and is therefore represented by $(Y'_{11})_2$. Similarly, coefficient matrices away from the leading diagonal represent cross-stiffness effects due to the deflections of the other joints.

For a structure with any number of joints, the set of matrix equations takes a form similar to (7) and (8). In the equation for a given joint, the coefficient matrix on the leading diagonal is the sum of the direct-stiffness matrices of the members meeting at that joint, the matrices chosen being either Y'_{11}, if the joint is at end 1, or Y'_{22} if at end 2 of the member. Coefficient matrices away from the leading diagonal represent the effects of all other joints directly coupled to the one considered.

It will be found in practice that, if the diagram is first labelled with arrows showing the direction of all the members, the synthesis of the set of load-displacement equations from the Y′ matrices is straightforward. As a check, it is useful to remember that the coefficients in the final set of linear equations must always form a symmetric matrix.

Extension of the Analysis to Space Frames.—The above analysis may easily be extended to cover frameworks in three dimensions. The load and displacement column-vectors will then have their full six components, while the four Y-matrices will be square matrices with six rows and columns (details of these matrices are given in Kron's original paper[1]). The orthogonal matrix T will also be more complicated, taking the general form $\begin{bmatrix} l_{ij} & 0 \\ 0 & l_{ij} \end{bmatrix}$, where l_{ij} represents the matrix of the direction cosines of the new axes referred to the old. With these extensions, the analysis becomes identical with that presented for a plane frame.

Modifications of the General Theory.—The analysis so far has applied to any structure with rigid joints. Its application to certain classes of problems, and the modifications required in certain circumstances, will now be considered.

In the case of a horizontal continuous beam with only vertical loading, equations (3) may be applied directly, since all the member and system co-ordinates may be made to coincide. Furthermore, all deflections and forces in the x-direction will be zero, and hence the first scalar equation of each of the matrix equations (3) becomes identically zero. Hence, the Y-matrices become 2 by 2 matrices, and loads and displacements have only two components. For a discussion of continuous-beam problems, the reader is referred to a paper by S. U. Benscoter.[2] It may be pointed out that, by this method of analysis, an allowance can easily be made for the effect of elastic supports. Assuming that at a certain point of support, s, the force and couple exerted by the support are $-k_1 y_s$, $-k_2 \psi_s$, respectively, (y_s and ψ_s being the deflection and rotation of the joint), the two scalar equations for the load at the joint will be of the form

$$\sum_i a_{is}\, y_i + b_{is}\, \psi_i = -k_1 y_s,$$
$$\sum_i c_{is}\, y_i + d_{is}\, \psi_i = -k_2 \psi_s.$$

Hence, all that is required is the addition of k_1, k_2 to the coefficients of y_s, ψ_s, on the left-hand side of the equations, and the joint may then be treated as if it were free and unloaded.

In order to lessen the redundancy of a rigid structure, it is often fixed to its foundations by pin joints. For instance, the effect of pin-jointing the ends A and B of the structure represented in Fig. 3 would be to alter the compatibility equations at those points. If the framework is connected to the pinned support by a single member, it is possible to modify the stiffness matrices of the member, and then consider it as if it were rigidly anchored at the pinned end. This is a more general case of the modification of the "carry-over" factor for a pin-supported member in the moment distribution method.

TABLE II.—*Coefficients for the Modified Matrices.*

End 1 pin-anchored	Y''_{12}	$-\frac{EA}{L}$	0	0
		0	$-\frac{3EI}{L^2}$	$\frac{3EI}{L^2}$
		0	0	0
	Y''_{22}	$\frac{EA}{L}$	0	0
		0	$\frac{3EI}{L^2}$	$-\frac{3EI}{L^2}$
		0	$-\frac{3EI}{L^2}$	$\frac{3EI}{L}$
End 2 pin-anchored	Y''_{11}	$\frac{EA}{L}$	0	0
		0	$\frac{3EI}{L^2}$	$\frac{3EI}{L^2}$
		0	$\frac{3EI}{L^2}$	$\frac{3EI}{L}$
	Y''_{21}	$-\frac{EA}{L}$	0	0
		0	$-\frac{3EI}{L^2}$	$-\frac{3EI}{L^2}$
		0	0	0

Consider a member pin-jointed to a rigid foundation at end 1; then equations (3) may be written as

$$F_1 = \begin{bmatrix} F_{x1} \\ F_{y1} \\ 0 \end{bmatrix} = Y_{11} \begin{bmatrix} 0 \\ 0 \\ \psi_1 \end{bmatrix} + Y_{12} D_2, \quad (10)$$

$$F_2 = Y_{21} \begin{bmatrix} 0 \\ 0 \\ \psi_1 \end{bmatrix} + Y_{22} D_2. \quad . \quad (11)$$

Equation (10) gives, considering the last of the three scalar equations,

$$0 = \left[0, \frac{6EI}{L^2}, \frac{4EI}{L}\right] \begin{bmatrix} 0 \\ 0 \\ \psi_1 \end{bmatrix} + \left[0, \frac{-6EI}{L^2}, \frac{2EI}{L}\right] D_2,$$

which, by simple manipulation, gives

$$\begin{bmatrix} 0 \\ 0 \\ \psi_1 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & \frac{3}{2L} & -\frac{1}{2} \end{bmatrix} D_2 = X_2 D_2,$$

where X_2 is defined by this equation. Substituting this in equations (10) and (11) gives

$$\left.\begin{aligned} F_1 &= [Y_{12} + Y_{11} X_2]\, D_2, \\ F_2 &= [Y_{22} + Y_{21} X_2]\, D_2. \end{aligned}\right\} \quad . \quad (12)$$

or, defining modified matrices as Y''_{12} and Y''_{22}, equations (12) can be re-written as

$$\left.\begin{aligned} F_1 &= Y''_{12} D_2, \\ F_2 &= Y''_{22} D_2, \end{aligned}\right\} \quad . \quad . \quad (13)$$

in which form they are similar to the equations for a rigidly-encastered member.

For a member with end 2 pin-supported, the analysis is similar. The matrix X_1 is given by

$$X_1 = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & \frac{-3}{2L} & -\frac{1}{2} \end{bmatrix},$$

and the modified matrices Y''_{11}, Y''_{21}, are defined by the equations

$$Y''_{11} = Y_{11} + Y_{12} X_1,$$
$$Y''_{21} = Y_{21} + Y_{22} X_1.$$

The components of these modified matrices are given in Table II, herewith. Transformations of these matrices follow the normal rules.

If, however, two or more members are rigidly attached to a joint which is pin-anchored (as, for instance, at the end of a bridge truss), modifications on the above lines become impracticable, and the following method should be adopted. If the joint displacement is D′$_s$, where x'_s, y'_s take prescribed zero values, and the applied couple M_{zs} is also zero, the three scalar equations for the joint should be constructed as if it were a normal one. The first two equations (containing the unknown reactions) should then be discarded, together with all coefficients of x'_s, y'_s occurring in the other equations. Thus, one equation will be added to the set of linear equations, corresponding to the extra variable ψ_s. This problem will be discussed later in the article.

The analysis of redundant pin-jointed frames is a straightforward special case of the general theory. It is clear that a pin-jointed frame is equivalent (for stress analysis purposes) to a rigid-jointed frame whose members have zero moments of inertia. In analysing the latter frame, the third scalar equation at each joint may be discarded, since no couples can be applied to the frame and joint rotations are irrelevant. Hence, end-loads F′, and displacement-vectors D′, become 2-vectors, and the Y-matrices become simply

$$Y_{11} = Y_{22} = \begin{bmatrix} \frac{EA}{L} & 0 \\ 0 & 0 \end{bmatrix},$$

$$Y_{21} = Y_{12} = \begin{bmatrix} \frac{-EA}{L} & 0 \\ 0 & 0 \end{bmatrix}.$$

In view of this simplification,

$$Y_{11} = Y_{22} = Y, \quad Y_{21} = Y_{12} = -Y.$$

The transformation matrix T is now given by

$$T = \begin{bmatrix} \cos\alpha & \sin\alpha \\ -\sin\alpha & \cos\alpha \end{bmatrix},$$

and equations (4) become

$$\left.\begin{aligned} F'_1 &= \quad Y' D'_1 - Y' D'_2, \\ F'_2 &= -Y' D'_1 + Y' D'_2, \end{aligned}\right\} \quad . \quad (14)$$

where

$$Y' = T^{-1} Y T = \frac{EA}{L} \begin{bmatrix} \cos^2\alpha, & \cos\alpha \sin\alpha \\ \cos\alpha \sin\alpha, & \sin^2\alpha \end{bmatrix}.$$

It now becomes unnecessary to number the members and the joints separately. If the joints are lettered a, b, c . . . members may be described by a pair of letters, r s, etc. (This was, of course, possible in dealing with rigid frames, but it would have been rather cumbersome.) At any joint n we have

$$\xi_n = \sum_m F' = D'_n \sum_m Y'_{nm} - \sum_m Y'_{nm} D'_m, \quad (15)$$

VARIABLE-GAUGE DIESEL-ELECTRIC LOCOMOTIVE.

FIG. 1. GENERAL VIEW OF LOCOMOTIVE.

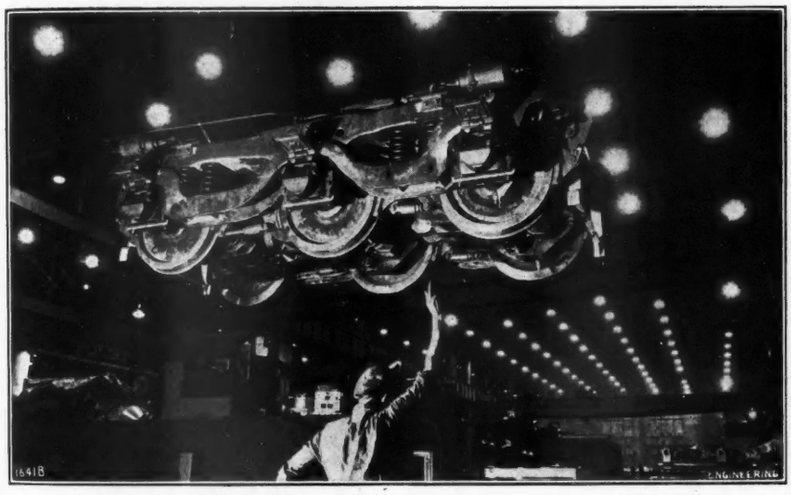


FIG. 2. VARIABLE-GAUGE BOGIE.

the symbol $\sum_m$ representing summation over all the other joints connected to the given one by a member. The solution of equations (15) may then be substituted in equations (14) to determine the stresses in the members in the usual way. For a discussion of the analysis of pin-jointed frames by matrix methods the reader is referred to a paper by Chen.[3]

REFERENCES.

[1] Kron, G., *Journal of the Franklin Institute*, vol. 238, No. 6, pages 399-442 (Dec. 1944).
[2] Benscoter, S. U., *Trans. American Society of Civil Engineers*, vol. 112, pages 1109-1172 (1947).
[3] Chen, P. P., *Trans. American Society of Civil Engineers*, vol. 114, pages 181-192 (1949).

(To be continued.)

660-VOLT LIMIT SWITCH.—A ball-headed plunger switch for controlling electrical circuits up to 660 volts has recently been introduced by Brook Motors, Ltd., Empress Works, Huddersfield. It is provided with low-resistance silver contacts and a plunger which carries a hardened steel rotating ball. This plunger has a maximum depression of about $\frac{3}{16}$ in., to secure which a pressure of 3 lb. is required. The switch is housed in a die-cast case which is rendered oil, water and dust resisting by a rubber gasket. There are two circuits, one for make and the other for break. The switch is intended for motor control or to act as a stop for limiting over-travel.

VARIABLE-GAUGE DIESEL-ELECTRIC LOCOMOTIVES.

A NUMBER of Diesel-electric locomotives, which it will be possible to operate on railways with different track gauges and anywhere in the world, are being built for the United States Army Transportation Corps by the American Locomotive Company, New York, and the General Electric Company, Schenectady. Some of these locomotives, a view of one of which is given in Fig. 1, have already been completed and a total of 83 are expected to be delivered by the end of the year. The specification laid down that the weight was not to exceed 120 tons, as compared with the 180 tons of a standard Alco shunting locomotive. Actually, it is limited to 20 tons on each axle, in spite of the fact that the locomotives have three-axle instead of two-axle bogies, and are equipped with an additional 800-gallon fuel tank. This modification in weight, and the correspondingly smaller dimensions, were necessitated by the weak road beds, light track and small loading gauges which are likely to be encountered. At the same time, it was laid down that the locomotives should have a tractive effort comparable with the standard unit and should be designed so that their gauge could be adjusted and the equipment employed over the widest temperature range.

Each locomotive is $13\frac{1}{2}$ ft. high above the rails, $56\frac{1}{2}$ ft. long, and $9\frac{1}{2}$ ft. wide. The power unit is a 1,600-h.p. 12-cylinder Diesel engine. This drives an electric generator, supplying current to a motor on each of the axles of the six-wheel bogies. The engine is supercharged so that it can develop extra power at high altitudes and is designed so that the locomotives can be used to haul passenger trains at speeds up to 65 m.p.h., or on goods trains, as well as for shunting. One of the bogies, which are fitted with extra long axles so that the locomotive can be employed on 5 ft., 5 ft. 3 in. or 5 ft. 6 in. gauges, is shown in Fig. 2.

Two oil-fired heaters are provided to enable the Diesel engine to be started when the atmospheric temperature is as low as — 65 deg. F. These warm a solution in a tank to a temperature of 60 deg. and circulate it round the fuel and cooling systems. Steam generators for heating the passenger vehicles are also to be installed on 50 of the locomotives. To permit operation in temperatures as high as 125 deg. F., a radiator of unusually large capacity is fitted and is cooled by a variable-speed fan.

LAND RECLAMATION IN NORTHERN INDIA AND PAKISTAN.

LAND reclamation, in India and Pakistan, is taken to mean the reclamation of otherwise good irrigable agricultural land which has gone out of cultivation, either due to water-logging brought about by a rise in the sub-soil water level, or due to the concentration near or on the surface of those salts inherently present in the soil. Rises in the sub-soil water level are inevitable and can only be combated by pumping and drainage, since they are attributed solely to seepage from the great irrigation canals and their distributing systems and the percolation of irrigation water and accumulations of rainfall (which are confined by the field boundaries) down to the water table below. Much information on the cause, prevention and cure of lands which have gone out of cultivation due to the concentration of salts near or on the surface is contained in a volume entitled *Land Reclamation*,* by M. L. Mehta, Director of Land Reclamation, Punjab, India, and it is apparent that, over the years, a technique has been developed which is bringing back into cultivation many tens of thousands of acres which have become salt-affected. This technique has been built up from experience gained in the pre-partition Punjab and dates from 1925, when the Irrigation Research Institute was established at Lahore.

The troublesome salts in the Punjab soil, which, to a large extent, is a comparatively thin crust of alluvium overlying sand which may extend downwards for several hundred feet and in which patches of clay occur sporadically and at all levels, are sodium sulphate, sodium chloride, and sodium carbonates. Investigation has shown, moreover, that in those areas which have gone out of cultivation due to salts concentrating near or on the surface, approximately 100 tons of salts per acre exist in the first 10 ft. of soil crust, with the degree of concentration diminishing with the depth and the pH value increasing from about 8·0 to nearly 10·0.

The theory advanced to account for this concentrating of salts is that, at first, the salts are evenly distributed in depth, but with the introduction of irrigation the salts go into solution and form a zone, or layer of accumulation. The subsequent position of this layer depends entirely on the intensity of the irrigation and the type of crops grown; if the quantity of water applied is sufficient to counterbalance that lost by transpiration and evaporation, then the layer will remain stationary, or even go lower; if, however, the quantity of irrigation water applied is insufficient to balance the losses, then the layer will move upwards. It will be seen, therefore, that a high water-table is not in itself a cause of salt concentration near or on the surface, although, where the water-table rises to within a foot or so

* Publication No. 43 of the Central Board of Irrigation, Simla, India.

NAVIGATION LIGHT FOR THE "AMBROSE" LIGHTSHIP.

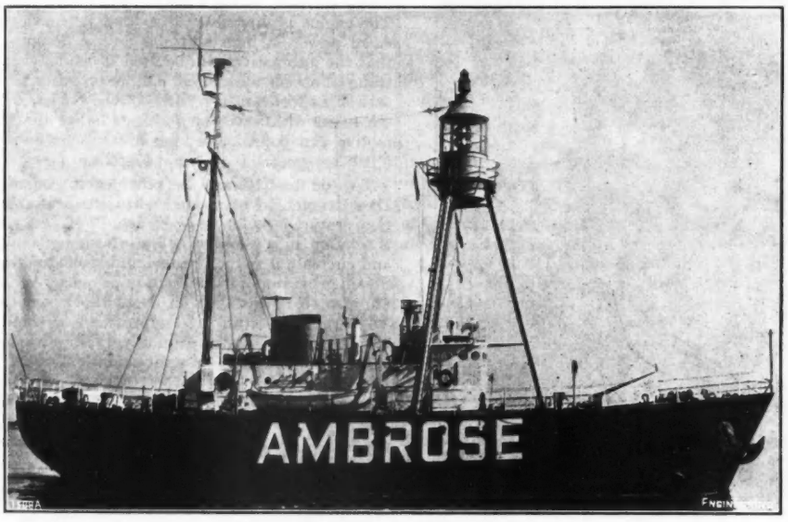


Fig. 1. "Ambrose" Lightship.

below the surface, salts may be driven to appear on the surface. Since different crops require different quantities of water, and water though abundant in the summer months, is often extremely scarce in the winter months, and since different crops occupy the land over different portions of the year, it follows that the nature of the crops grown is also an important factor. As it is desirable to balance evaporation and transpiration against water supplied and its period of availability, the growing of cotton (which is a deep feeder), for example, will draw the salt layer upwards, while the growing of rice, which requires much water during the summer months, will have a reverse effect. Experiments with a rice/fallow rotation have resulted in the soluble salts being reduced from a maximum of 0·6 per cent. of air-dried earth taken from a depth of 6 ft. below the surface, to 0·15 to 0·08 per cent. over a range of from 1 to 15 ft. below the surface.

The concentration of salts, however, is but the first stage in soil deterioration; the second stage is more serious, as the soil conditions resulting are more difficult to correct. This secondary stage is termed "base exchange" and the reaction between the calcium clay soil and the sodium salts may be expressed as:—Na_2SO_4 + Ca-clay = Na_2-clay (alkaline) + $CaSO_4$. This development of alkalinity of the soil is a gradual process and in its later stages the clay becomes deflocculated and the soil becomes more or less impermeable to water; it is stated that the surface can become so hard that in the case of an occurrence in the Karnal district a pick-axe was unable to penetrate it. The cultivation of such a soil is then rendered practically impossible as it becomes too hard in summer and too sticky in winter. The importance, therefore, of preventing the second stage from developing is apparent.

Scottish Industries Exhibition.—An exhibition devoted to Scottish industries will be held at Kelvin Hall, Glasgow, from Thursday, September 2, to Saturday, September 18, 1954. Communications should be addressed to the general manager, Scottish Industries Exhibition, 16, Woodside-terrace, Glasgow, C.3.

Fourth Anglo-American Aeronautical Conference.—Owing to the large number of delegates who will attend the fourth Anglo-American Aeronautical Conference, which is to be held in London from September 15 to 17, all the lectures, as well as the opening and closing sessions, will be held at Friends House, Euston-road, London, N.W.1, and not, as previously announced, at University College, London. The Royal Aeronautical Society state that visitors will be welcome at the opening and closing sessions, at 9.30 a.m. on September 15, and 4 p.m. on September 17, respectively.

NAVIGATION LIGHT FOR "AMBROSE" LIGHTSHIP.

The most powerful sea navigation light of its kind in the world, with a maximum beam power of 5,560,000 international candles, has been installed in the Ambrose lightship, which returned to its station 30 miles from New York last May, after re-commissioning by the United States Coast Guard. The Ambrose lightship, shown in Fig. 1, is an important sea mark to shipping approaching New York Harbour, and it is also the starting reference point on the west-to-east run for the Blue Riband trans-Atlantic crossing record. The new apparatus was made by Chance Brothers, Limited, Smethwick, Birmingham, in collaboration with the Testing and Development Division of the United States Coast Guard and the engineering staff of Trinity House. It is basically similar to equipment designed by Trinity House and manufactured by Chance Brothers for British lightships which have been in operation for some years.

The apparatus, shown in Fig. 2, comprises a pendulum on double gimbal bearings, with the optical equipment situated above the bearing mounting. The purpose of this arrangement is to transmit the light beams from the optic sensibly parallel to the sea, to ensure continuous visibility to the mariner regardless of rolling or pitching of the lightship. Adjustment is provided within the weight box of the pendulum to cater for a relatively wide range of vessel period (i.e., 9 to 23 seconds), and allows for a maximum angle of roll or pitch of the vessel of 29 deg. The optical equipment consists of four pairs of 18-in. by 6-in. focus mirrors arranged in tandem in a vertical plane, with a 1,000-watt high-efficiency lamp at the focus of each mirror. Thus, a failure of a single lamp in any one pair of mirrors means only a temporary loss of candlepower of one aspect and does not destroy the identification of the flashing character exhibited by the light. A system of current-flow detection relays is employed to indicate lamp-filament failure.

The flashing character of the light is obtained by rotating the optical apparatus by means of an electric motor; there is provision for a wide range of both flash characteristic and speed of rotation, to make the vessel serviceable at stations requiring different characters. Flexibility of flashing is made possible by selecting the number of aspects employed and by the angular displacement of the aspects relative to each other in the horizontal plane. Changes in speed of rotation of the optic are provided for by a selection of gear change-wheels.

With the maximum beam candlepower emitted by this apparatus it would be possible for the light to be seen from a distance of 64 sea miles on a tropically-clear night, if the earth's curvature permitted such a geographical range at sea-level. The purpose of so high a beam candlepower, however, is not for clear-weather conditions, but to enable the light to be visible when atmospheric conditions are misty or even foggy. Assuming that the light would be visible at 46½ sea miles in clear weather (with an atmospheric transmission as high as 0·85), at 0·60 the range would be reduced to 18½ sea miles, and at 0·5 (representing a daylight visibility of six sea miles) the light would be seen at 14 sea miles. To deal with such varying atmospheric conditions, the United States Coast Guard development engineers decided to incorporate a system of voltage control, so that the candlepower can be selected according to prevailing atmospheric conditions. Thus, at the maximum operating voltage the beam power will be 5,560,000 candles, at 80 per cent. voltage 2,780,000 candles, at 65 per cent. voltage 1,390,000 candles, and at 40 per cent. 278,000 candles.

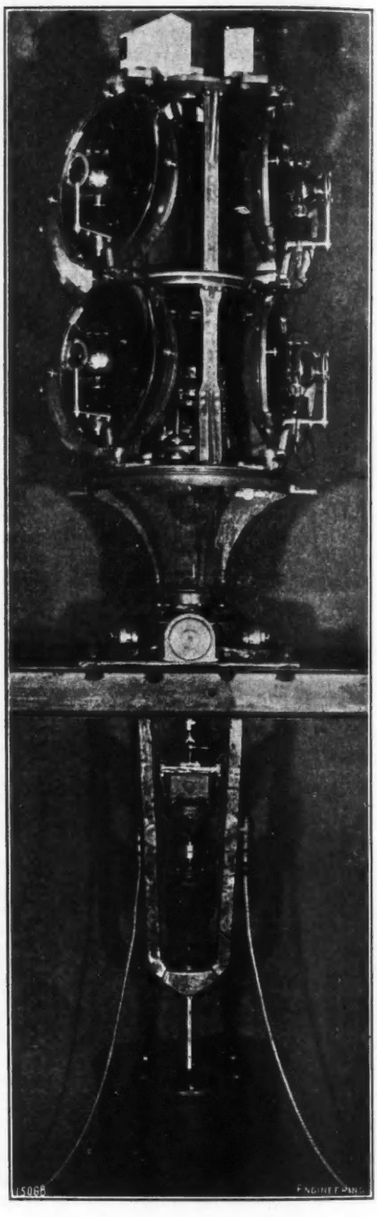
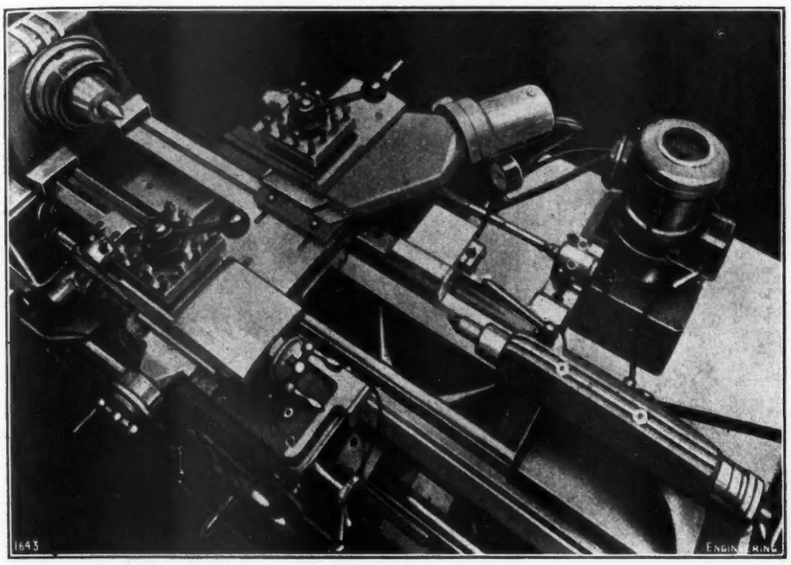


Fig. 2. Navigation Light on Double Gimbal Bearings.

COPYING ATTACHMENT FOR LATHES.



HYDRAULIC COPYING ATTACHMENT FOR LATHES.

THE accompanying illustration shows an attachment designed for converting ordinary centre lathes for copying work; it is made by the GEMA, Betriebsgesellschaft m.b.H., St. Ingbert, Saar. The agents for the equipment in this country and the Commonwealth are the Ray-Tyler Engineering Company, Limited, 87, Bishopsgate, London, E.C.2. It can be fitted to lathes having a maximum swing over the bed of 6 in. The cross travel of a tool mounted in the attachment is 5 in. and it will turn parts up to maximum length of 1 ft. 10 in. The maximum depth of cut depends upon the capacity of the lathe to which it is fitted, as the power feed for the tool is taken from the leadscrew. It is recommended that the horse-power of the lathe should not exceed 5, which would enable a cut $\frac{3}{8}$ in. deep to be taken.

The Copytor has been arranged for mounting at the rear of the bed and saddle, the cast-iron bracket with centres for supporting the model to be copied being screwed to the rear of the bed, while the plate carrying the tool post and copying attachment fits directly on to the existing saddle of the lathe; an adapter plate to suit different makes of lathe is supplied with the attachment. An electric motor and pump, working at a pressure of 40 lb. per square inch, is included in the equipment and can be mounted in any convenient position. It is claimed that the low working pressure of the pump reduces the possibility of leakage. The pressure is applied to a hydraulic cylinder at the rear of the top slide which is actuated by the stylus as it passes over the template, and feeds the tool to the workpiece. The pressure on the stylus is 2 lb. The feed pressure is adjusted by a small grub-screw, a gauge being fitted to indicate the pressure. The top-slide setting can be adjusted by a micrometer type of hand screw fitted at the rear and the control lever for the hydraulic feed is fitted with a long flexible lead so that it can be attached to the front of the lathe saddle.

To use the attachment it is first necessary to produce a template or model. This can be made on the same lathe by use of the front tool post. The model is then mounted in the centres of the template support with the stylus in position, the material to be turned is fitted between the lathe centres and the hydraulic control set in action. It is claimed that all parts produced by this method are identical within very fine limits. It is also suggested that one man could easily operate three machines fitted with the attachment thereby economising in labour costs. For aligning the travel of the tool, two ground cylindrical testpieces having parallel surfaces can be fitted, one in place of the model and the other in the lathe centres, a dial gauge being fitted in place of the tool for checking the accuracy of the travel. Another claim made for the use of this equipment is that it can be used economically if more than three similar parts are required, no skill being necessary after the first part has been made.

AUTOMATIC-CONTROL EQUIPMENT FOR DIESEL ENGINES.

MIRRLEES, BICKERTON AND DAY, LIMITED, Stockport, have introduced automatic-control equipment for use with their J and K ranges of Diesel engines. The purpose of this equipment is to record any breakdown that occurs in the mains supply of electricity and to start up Diesel-driven generators immediately in order to maintain the supply. The control also stops the engine when the mains supply is restored. Both the J and K engines, to which this equipment can be fitted, are built in the in-line and the V-form. They are naturally aspirated, pressure-charged and high pressure-charged with air intercoolers. The J engines are made in various sizes of from three to 16 cylinders, cover a power range of 165 to 2,500 brake horse-power, and are suitable for speeds up to 1,000 r.p.m. The K range of engines may have from five to 12 cylinders, a power range from 485 to 3,000 brake horse-power, and operate at speeds up to 450 r.p.m. The description of the automatic-control equipment which follows refers to the J range of Mirrlees engine only, but the principles employed are suitable for application to other types of Diesel engines.

The control equipment is electrically operated by current drawn from batteries. When the mains supply, which is linked with the automatic control, fails a relay in the equipment closes, bringing the battery supply into circuit. This initiates what is termed a "Start On" signal which is picked up by a relay on the control panel; at the same time a motor-driven pump comes into operation to ensure that the lubrication system of engine is fully primed. The crankshaft of the engine is not permitted to move until a suitable oil pressure has been attained. Meanwhile, a system of valves, which are operated by a solenoid and interlock with the fuel and lubricating systems, open to permit the compressed air used for turning-over the engine to pass to the engine cylinders. At this stage the control-shaft of the fuel pump remains in the closed position. After a period of two to three seconds, a solenoid releases the control-shaft of the fuel pump and the pump governor takes over. Fuel is injected into the cylinder already charged with compressed air, and the engine fires within the first two or three seconds. After starting, a centrifugal switch, driven through a flexible coupling and mounted at the front end of the engine, de-energises the starting circuits and brings into operation an alarm system; this takes place at half the normal engine speed. At full speed, a second centrifugal switch transmits a signal to the control panel to indicate that the engine is ready to take full load. If the engine fails to fire, a time switch controlling the compressed-air supply closes the appropriate valve and brings the engine to rest. Meanwhile, the relays are re-set automatically and the starting cycle begins again. Repeat starts continue at intervals of 15 seconds for a total period of 120 seconds. If, however, the engine has not fired at the end of this time, the starting circuit cuts out, a Klaxon horn is sounded and a lamp on the control panel labelled "Engine Locked Out" is illuminated.

When the mains supply is restored, one of the relays energises the solenoid on the fuel pump and moves the control-shaft across, closing the fuel supply. Approximately 90 seconds after the engine stops the relays are re-set for a future emergency.

Some additional controls are fitted to protect the engine and these ensure that it will cease to function if any fault occurs. They include a switch for registering the flow of water and two thermostats; one thermostat sounds a Klaxon horn when the cooling water temperature rises above a predetermined figure, and the other stops the engine if the temperature continues to rise. Centrifugally-operated switches keep a check on the engine speed, and if this speed rises to $12\frac{1}{2}$ per cent. above normal a stop is effected. A mechanical type of centrifugal cut-out is also provided and this operates at 50 r.p.m. higher than the electrical control. A manually-operated switch stops the warning Klaxon and when it is operated a light appears on the control panel to indicate that the engine is receiving attention. Other lights on the panel indicate the nature of the engine fault, or its immediate operating condition. The automatic-control equipment described is also interconnected with the normal system of manual control for the set, so that hand starting can be used for maintenance or other purposes. Additional relays and control gear for synchronising, where more than one generator is installed, cascade starting of two or more electric motors for the pumps or fans used in the cooling system and the interlocking of the main switchgear, are also available and can be built into the cabinet that contains the control relays.

CREWE PUPILS AND PREMIUM APPRENTICES.—An annual dinner of past and present Crewe pupils and premium apprentices is to be held in October if there is a sufficient response. Mr. R. A. Riddles is to lay the foundation stone of a new apprentices' school on the site of the old carriage shops at Crewe, and it was thought that this would be a good opportunity to hold the 50th dinner—the last was held on May 5, 1939—at the Crewe Arms Hotel. Arrangements are being made by Mr. Eric A. Robinson, of the Superheater Co., Ltd., 53, Haymarket, London, S.W.1.

"GEAR SHAVING": ERRATA.—On page 825 of our issue of June 26 we gave an abridged report of a paper on gear shaving which had been presented at a meeting of the British Gear Manufacturers Association. The author's name was incorrectly stated; it should have been A. Sykes, who is technical director of the Gear Group of the David Brown Companies. We regret the error and any misunderstanding which may have been caused. In the fifth paragraph on page 825 the terms "lead" and "leading" should have been "load" and "loading."

INVENTIONS COMPETITION OF ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—Mr. A. W. Pelerin, Kingsbury, London, has been awarded the inventions trophy of the Association of Supervising Electrical Engineers, together with a prize of 10*l.* presented by Dr. A. P. Thurston, M.B.E., M.I.Mech.E., for his design of a tandem brush holder. Mr. L. Middlemiss, Leeds, was specially commended for his entry, an electronic interval-timer. The trophy and prize are awarded annually on the result of an inventions competition, which is limited to members of the Association.

LONG-RANGE MARINE RADAR EQUIPMENT.

KELVIN AND HUGHES (MARINE) LTD., LONDON.

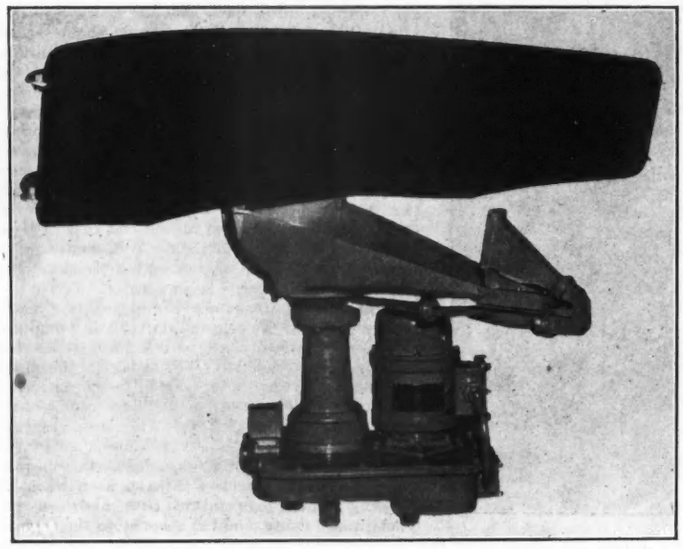


FIG. 1. SCANNER OF TYPE 2C MARINE RADAR EQUIPMENT.

FIG. 2. DISPLAY UNIT.

KELVIN HUGHES LONG-RANGE RADAR EQUIPMENT FOR SHIPS.

WE recently had an opportunity of witnessing a demonstration of the latest type of marine radar equipment which has been developed by Kelvin and Hughes (Marine), Limited, 99, Fenchurch-street, London, E.C.3. The scanner, a photograph of which is reproduced in Fig. 1, on this page, was erected on the roof of the company's new offices at 21, Mincing-lane, the other components being mounted in a room on the top floor of the building. The principles and method of operation are generally similar to those briefly explained in ENGINEERING, vol. 172, page 255 (1951), but it is claimed that in the new apparatus, known as Type 2C, improvements in electronic equipment and engineering design have enabled an all-round advance in operational performance to be obtained without adding to the initial or maintenance costs.

A particularly important feature of the new equipment is the addition of a long-range searcher scale covering an area of 50 sea miles radius. The range of radar detection is, of course, essentially limited by the horizon, but experience has shown that there are many targets along the world's trade routes having characteristics suitable for detection at longer ranges than have been obtained previously with standard equipment. Such targets, when identifiable, are obviously very helpful for fixing the ship's position.

The Type 2C set has a 12-in. plan-position indicator, illustrated in Fig. 2, with four scale ranges. The first of these covers distances from one to five miles, and is used when the ship is working in estuaries and other narrow channels. This scale is continuously variable between its limits, and the most useful intermediate scale can be selected instantaneously. The second scale covers a radius of 10 miles, and has been found to be a most satisfactory scale range for coastwise pilotage for keeping a general look-out when proceeding in conditions of poor visibility. The third scale, with a maximum range of 25 miles, is suitable for the long-range detection of average targets, and the fourth is a long-range searcher scale for position finding at distances up to 50 miles. It is pointed out, however, that the design features that provide for detection at 50 miles also result in longer detection ranges for average targets, such as buoys, general shipping and low coastlines. It is also claimed that results on the very short ranges are correspondingly improved, giving clarity, accuracy and discrimination of a very high order.

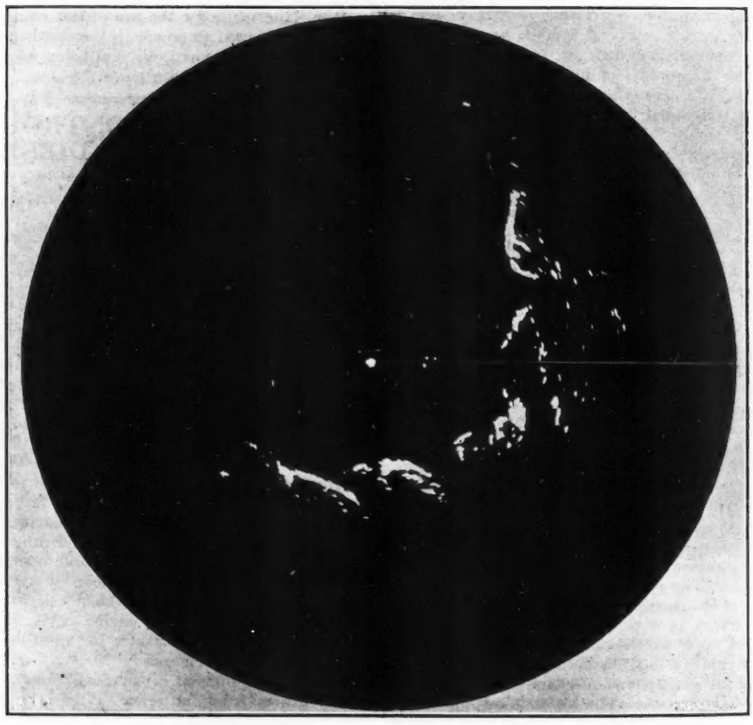


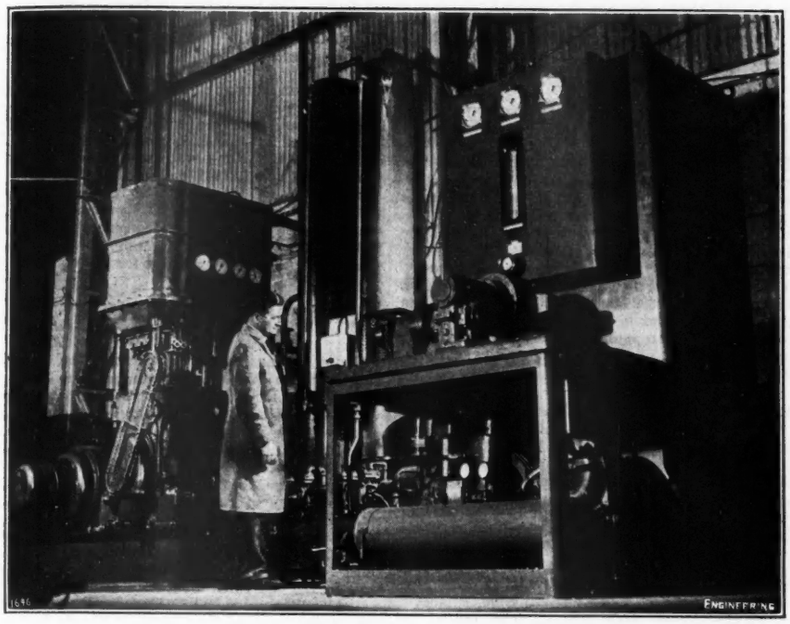
FIG. 3. LONG-RANGE INDICATION OBTAINED WHEN APPROACHING LIVERPOOL.

The means for obtaining distance and bearings of objects shown on the plan-position indicator of the display unit are similar to those described in the previous article referred to above. Distances can be estimated from the positions of the objects relatively to a series of concentric rings which appear on the indicator and represent distances of half a mile, 2 miles, 4 miles and 8 miles, respectively, on the four scales. For the closer measurement of distances, the radius of a superimposed ring on the indicator can be adjusted by a calibrated control until the circle cuts the object of which the distance is required; the distance can then be read from an indicator on the face of the display unit. Bearings can be measured by means of a cursor, which can be rotated about the centre of the screen of the indicator, readings being taken on a circumferential scale of angles. The zero of this scale can be referred to the ship's head or to the North Point.

It will be readily understood that the innumerable tall buildings within a five-mile radius from Mincing-lane made the plan shown on the indicator in the demonstration difficult to interpret. The course of the Thames and some of the bridges could be clearly distinguished; but the conditions.

OXYGEN-GENERATING PLANT.

THE BUTTERLEY COMPANY, LIMITED, LONDON.



of course, were entirely different from those experienced at sea, which are well illustrated by the photograph reproduced in Fig. 3. This was taken from the indicator of a vessel approaching Liverpool, with the 50-mile scale in use. The horizontal line on the right is the heading line and indicates the direction in which the vessel was proceeding at the time. Near the inner end of this line are three spots, the largest of which indicates the Bar light vessel; the other two indicate small vessels in the vicinity. Small points to the right of these, hardly visible in the reproduction, indicate the buoyed channel leading to the Mersey. Near the periphery of the illustration, in an angular position representing approximately one hour on a clock dial, is a spot indicating the position of Barrow, at a distance of 35 miles, and below this, a little to the right, is an approximately vertical streak representing the Fylde Coast of Lancashire at a distance of 21 miles. The curvature of the lower end of this streak indicates the mouth of the River Ribble. The streaks and spots below the heading line curving round towards the left represent the north coast of Wales, the single isolated spot at the left-hand end indicating Great Ormes Head at a distance of 17 miles from the vessel.

The fairly large spot near the inner end of the heading line is an interesting feature of the equipment which needs some explanation. It is produced by a monitoring set mounted on the ship's funnel which receives some of the energy from the scanner and returns it to the main receiver so that it appears on the plan-position indicator. When the long-range scale is in use a somewhat distorted circular spot appears, as shown in Fig. 3, but with the shorter-range scales a kind of "comet's tail" appears appended to the spot, the length of the tail being a measure of the strength of the transmission. This useful feature serves to inform the officer using the equipment that it is functioning correctly.

Radar has long since passed the experimental stage as a navigational aid, but any improvements in the reliability and effectiveness of the apparatus will certainly be of interest to the shipping industry.

NEW 240-MW POWER STATION.—The British Electricity Authority have received the consent of the Ministry of Fuel and Power to build a new power station at South Denes, Great Yarmouth. The equipment will consist of four 60-MW turbo-generators, each of which will be supplied from a single boiler with an output of 550,000 lb. of steam per hour.

OXYGEN-GENERATING PLANT FOR INDUSTRIAL AND MOBILE USE.

OXYGEN and nitrogen generating plants suitable for installing in industrial and medical establishments, and for mobile use in, for example, the Armed Forces, are now being made by the Butterley Company, Limited, Oxygen Division, 20, Ashley-place, Victoria, London, S.W.1. These "Oxygenerators," as they are called, are notably compact and the makers say that they will ensure a constant unfailing supply at a cost per cubic foot which will show considerable savings over the normal sources of supply. They are being made under licence from Air Products Inc., U.S.A., and are to be shown at the Engineering, Marine and Welding Exhibition, which opens at Olympia, London, on Thursday, September 3.

The range of Oxygenerators consists of 14 standard models which produce moisture-free oxygen with a purity of 99·5 per cent., or higher, compressed to 2,000 lb. per square inch (or higher, if specified), at rates of from 300 cub. ft. (8·5 cub. m.) to 12,000 cub. ft. (340 cub. m.) per hour. The larger models can also produce, simultaneously with the oxygen, dry nitrogen of 99·9 per cent. purity and, with a simple modification, crude dry argon. The nitrogen capacities of standard models range up to 35,000 cub. ft. (1,000 cub. m.) per hour. The smaller models will produce 99·5 per cent. minimum purity nitrogen, but not simultaneously with oxygen.

The chief technical feature of the plant is a patented liquid-oxygen pump, which eliminates the need for an oxygen compressor (high in maintenance costs) and a bulky oxygen gas holder and oxygen drier, which are used in older designs. The power consumed by the Oxygenerators is stated to be relatively small, and only one part-time operator is required per shift for operation and maintenance. The smaller models are readily housed in an existing building close to the point of use, and the cost of installing and maintaining oxygen pipe-lines depends solely on the siting of the plant in relation to the points it serves. The Oxygenerators can be shut down over week-ends, or for longer periods, without incurring the troubles with defrosting which are usual with most systems.

There are three series of Oxygenerators: the R, RD and E series. The oxygen production rate for the R and RD series ranges from 300 to 2,500 cub. ft. per hour (99·5 per cent. minimum purity at a pressure of 180 atmospheres, though the rate is based on measurement at conditions of 20 deg. C. and one atmosphere absolute; higher purities are readily obtained with a slight reduction in production rate). The nitrogen production rate (99·5 per cent. minimum purity and compressed to 180 atmospheres) is from 500 cub. ft. per hour for the second smallest model to 2,500 cub. ft. per hour for the largest. Liquid oxygen or liquid air can be produced, if required, at rates ranging from 10 lb. to 70 lb. per hour, and liquid nitrogen at rates from 27 lb. per hour in the second smallest model to 65 lb. per hour in the largest. The starting time, after defrosting, is between about 3½ and 6 hours, depending on the size of the plant. The starting time after an eight-hour shut-down is from 1 to 2 hours.

An Oxygenerator in the R or RD series consists of an air compressor, air purifier, air drier, and air separator. The air compressor is a multi-stage low-speed machine with an electric-motor drive, though other forms of prime mover can be supplied. The air purifier removes the carbon dioxide, thereby preventing the plant from freezing up. Purification takes place after the first stage of compression, thus enabling the purifier to be kept reasonably small and compact. In the air-separation unit, drying, cooling, liquefaction and distillation take place. The unit also contains the liquid-oxygen pump which delivers the oxygen (or nitrogen) into a storage bank and pipe-lines, or to a cylinder-charging manifold. The connected electric horse-power is from 30 to 154, though the actual power demand during normal operation is somewhat less because the normal air-compressor load is lower than the starting load, the air refrigerator is ordinarily used for starting only, and the air-drier heater is not used continuously. The operator's time for controlling the plant is about 15 to 20 minutes per hour.

The larger, E series, machines comprise six models with oxygen-production rates from 2,500 to 12,000 cub. ft. per hour; nitrogen rates from 2,500 to 12,300 cub. ft. per hour; liquid oxygen or air from 70 to 250 lb. per hour; and liquid nitrogen from 65 to 230 lb. per hour. Arrangements can also be made for a very high production of dry nitrogen, simultaneously with oxygen production, in the case of the three largest models. The starting time ranges from 6 to 8 hours after defrosting, but is 2 hours for all models after an 8-hour shut-down. The connected electric horse-power is from 160 to 546, and the cooling-water rate, at a 20-deg. F. rise, is from 40 to 155 gallons per minute. The approximate floor dimensions required are from 20 ft. by 30 ft. to 30 ft. by 50 ft., and the operator's time amounts to about 30 minutes per hour.

LECTURES ON GAS TURBINES.—Mr. Roy C. Orford, M.Sc., C.P.A., A.M.I.E.E., patents manager of Power Jets (Research and Development), Ltd., is to deliver ten evening lectures on gas-turbine technology at the South East London Technical College, Lewisham-way, London, S.E.4. These lectures will be given at weekly intervals, commencing on Tuesday, October 13, 1953. The fee for the course is 1*l.* 15*s.*

ENFORCEMENT OF INDUSTRIAL INJURIES ACT.—An Order has been issued by Mr. Osbert Peake, the Minister of National Insurance, fixing August 26 next as the date when the provisions of the National Insurance (Industrial Injuries) Act, 1953, shall come into operation. Although the essentials of the scheme of insurance against industrial injuries will remain unaltered, the new Act provides for a number of changes in the payment of benefits. Contributions, however, will not be increased.

9-KW ELECTRIC IMMERSION HEATER.—A 9-kW immersion heater, which has been developed by the General Electric Co., Ltd., Kingsway, London, W.C.2, is designed so that industrial water tanks and cylinders which are now fired by solid fuel or gas can be converted to electric heating. It consists of a brass head which carries three heating tubes, from which the cartridge elements can be withdrawn without draining the container, the construction being such that the spirals are protected from oxidation. The three elements are connected in star and their operating temperature is calculated to ensure a trouble-free life.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

FUEL EFFICIENCY SERVICES.—The Scottish Fuel Efficiency Committee have been meeting in Glasgow to consider the Government's proposal to set up a non-profit-making organisation to take over fuel-efficiency services and to operate them independently of the Government. Opinions appear to be divided as to whether the new organisation will succeed in promoting fuel efficiency in Scotland as well as the existing fuel efficiency committee have done. Meanwhile, the committee have received a letter from the Ministry of Fuel and Power stating that it is impossible to give any information regarding the new project until the objects and constitution of the new organisation have been drafted.

FACTORY REMOVAL TO EAST KILBRIDE.—Hayward, Tyler & Co., Ltd., general engineers, are to transfer, in about a year, their branch factory at the Marine Gardens, Portobello, Edinburgh, to a new building under erection at East Kilbride. The move has been necessitated by the ending of the requisition period of the Government property on which the premises are located. The employees, numbering between 80 and 90, have been invited to transfer to East Kilbride.

THE PORT OF LEITH.—The Commissioners for the harbour and docks of Leith have brought out the first issue of a new handbook called *The Port of Leith* which should prove of interest to all who use the port. Information on rates and charges, and data on the industries of Leith and the facilities of the port are given.

LUING AND SEIL ISLANDS FERRY.—The two slipways for the new vehicle ferry linking Luing Island with Seil Island and the mainland of Argyll have been practically completed and the service is expected to be operating at the end of this month. Apart from opening up Luing for tourist traffic the new ferry, which is to be free, will be of particular importance for the slate quarries on the island. These have hitherto depended on "puffers"—small steam or motor-driven coasting vessels—for the transport of slates to the mainland.

CLEVELAND AND THE NORTHERN COUNTIES.

THE LATE MR. R. H. MATTHEWS.—Mr. Robert H. Matthews, of Jarrow-on-Tyne, who retired 11 years ago from the post of dock manager with the Mercantile Dry Dock Co., Ltd., Jarrow, has died at the age of 76. He was with the firm for 45 years and had supervised the docking of more than 3,000 ships.

NORTH-EAST COAST SHIPBUILDING INDUSTRY.—The holiday season for Tyne shipyard and engineering employees is drawing to a close. Last week many thousands of men were back at work after their holiday, and a further batch returned to work last Monday. Between 5,000 and 6,000 ship-repairing employees, the last batch to be on holiday, will return to work on August 24. The latest Ministry of Labour report for the Northern Region states that employment in shipbuilding, ship-repairing and marine engineering continues at a high level, and that skilled men, especially electricians, ships' painters and platers, shipwrights, welders and fitters, were in demand.

DUST AND STEAM FROM COKE-OVEN PLANT.—Reference to Dorman, Long & Co's proposals for dealing with dust and steam from their Cleveland Works was made at a meeting of Eston (Yorkshire) Planning Committee. A Government inspector's report stated that the firm's coke-oven plant proposals contained many desirable features to prevent smoke and grit escaping, but it was suggested that further efforts could be made to prevent pollution. The report pointed out, however, that there were no known methods of completely eliminating the production of dust and steam during the quenching of hot coke, which is one of the principal causes of complaint.

PRE-APPRENTICESHIP COURSE AT CONSETT.—The Consett Iron Co., Ltd., Co. Durham, have launched, as an experiment, a pre-apprenticeship course lasting three days. Fourteen boys attended the first course and were given information concerning the firm's activities, accident prevention, conditions of employment, trade unionism, research and craftsmanship. There were also films and a tour of the works. The courses are to be held twice a year. On the conclusion of the three-day course the 14 boys began work with the company.

THE LATE MR. J. W. COTTEE.—The death has taken place at Sunderland of Mr. Joseph William Cottee, who retired some time ago from the post of managing director of the Sunderland shipping firm of James Westoll, Ltd., but retained his seat as a director. Mr. Cottee, who was 76 years old, had been with the firm for 60 years. He became general manager in 1926, and subsequently was appointed managing director. He was formerly a member of the River Wear Commissioners.

LANCASHIRE AND SOUTH YORKSHIRE.

ENGINEERING EDUCATION IN MANCHESTER.—Two pamphlets, "Engineering Education" and "Post-Advanced Lectures in Electrical and Mechanical Engineering" have been sent to us by the Manchester and District Advisory Council for Further Education, Education Offices, Deansgate, Manchester, 3. The first pamphlet is a guide to engineering education and to the facilities existing for the study of engineering in all its branches in the Manchester area. The second pamphlet, on post-advanced lectures, is intended for persons who desire to pursue their studies after having reached a standard at least equivalent to the Higher National Certificate.

RESEARCH LABORATORIES.—The new laboratories at Sheffield of the British Iron and Steel Research Association, to be opened by the Duke of Edinburgh on November 19, are on a two-and-a-half-acre site and include a three-storey block and two single-storey plant buildings. Among the plant installed is a steel-making arc furnace, a rolling mill capable of cold-rolling strip at 1,750 ft. a minute, and a new experimental wire-drawing machine. There is a high-frequency furnace to melt steel in vacuum; it will be used for producing pure iron and special alloys.

SHEFFIELD STEEL PRODUCTION.—The output of steel in Sheffield in June increased by 900 tons a week to 47,100 tons a week. It included more than half of the total 18,100 tons a week of electrically-produced steel made in Britain. The output of semi-finished steel of 15,700 tons a week was high, but special alloy-steels manufacture declined by 2,000 tons a week to 13,320 tons.

THE MIDLANDS.

TEMPORARY CLOSING OF KILSBY TUNNEL.—Kilsby tunnel, on the main line of British Railways from London (Euston) to Birmingham (New Street), is to be closed temporarily for repairs on September 28. The tunnel, which is about four miles south-east of Rugby, is nearly a mile and a half long, and was opened in September, 1838. Difficulties have been experienced with the drainage of the tunnel for sometime—a trouble which greatly retarded its construction and enormously increased its original cost—and the closure is for the purpose of laying new drains. The tracks and ballast will be removed, the drains laid, and the tracks replaced. The work is scheduled to be completed by October 31. While the tunnel is closed, passenger traffic will be diverted via Northampton, on a loop line which leaves the main line at Blisworth and rejoins it at Rugby. Stations on the main line which are out of use as a result of the tunnel closure will be served by special 'buses. Freight traffic will be diverted over a number of routes.

METHOD STUDY IN BUILDING.—John McLean & Sons, Ltd., Coven, Wolverhampton, claim to be the first firm in the Midlands to apply time and motion study to building. They are building a housing estate at Dudley, Worcestershire, and have employed time and motion study consultants to examine their methods, with a view to increasing efficiency. Times have been set for each job, and bonuses are paid at the standard hourly rate. The scheme has been in operation for five months, and the work is said to be proceeding faster than the average for the district. Wage increases of up to 50 per cent. are being earned.

CANAL LEVEL RESTORED BY FIRE-BRIGADE PUMPS.—Wolverhampton Fire Brigade were engaged from 4.30 p.m. until midnight on August 7 to pump water from the Shropshire Union Canal to the Staffordshire and Worcestershire Canal at Autherley Junction, Wolverhampton, in order to raise the level of the latter canal sufficiently for a number of loaded boats to proceed. A part of the Staffordshire and Worcestershire Canal north of the junction had been closed for repairs, and, though water courses flowing into it should have maintained the level, these supplies proved insufficient, and about 12 boats, proceeding south, were found to be aground. The stoppage north of Autherley Junction was cleared on August 10, and normal water supplies were restored.

TESTS OF A DIESEL TRAIN.—A three-car light-alloy Diesel train is being used experimentally on the Western Region of British Railways, in the Birmingham-Wolverhampton district. The train is based on Birmingham, and is in operation for about 14 hours a day between that city and various stations within 15 miles. The train crew are provided with questionnaire forms for passengers to complete, and it is hoped to obtain valuable information on the subject of passenger reaction.

SEWER-LAYING UNDER THE GRAND UNION CANAL.—Advantage was taken of the reduced traffic during the industrial holiday to drain the main line of the Grand Union Canal at Emscote, Warwickshire, and lay a sewer through it to serve a new housing estate. It was originally intended to tunnel under the canal, but preliminary work showed this to be impracticable, and the "cut and fill" method was decided upon. The canal carries a considerable amount of traffic at this part, and the stoppage was limited to ten days, with a heavy penalty for any excess.

SOUTH-WEST ENGLAND AND SOUTH WALES.

SOUTH WALES COAL INDUSTRY.—The output of coal in South Wales and Monmouthshire during the August Bank Holiday week was 174,800 tons, compared with 349,731 tons in the preceding seven days. In the corresponding period of last year it amounted to 182,730 tons, but, as different areas of the coalfield were taking their annual holidays during the periods, the figures are not truly comparable. South Wales coal shipments to France, which, after flowing at the rate of 100,000 tons a month in the closing stages of last year, were cut, owing to the economic position in France, to only 14,000 tons for each of the second and third quarters of this year, will be resumed on a larger scale in the last three months of 1953. France, it is stated, will buy 100,000 tons of British coals during this period, and of this quantity South Wales will supply 80,000 tons.

LARGE SHIPMENT OF COKE TO BUENOS AIRES.—What is thought to be the largest single shipment of coke ever made from the South Wales ports has been loaded during the past week at Cardiff in the S.S. Chamois. It amounted to 5,200 tons of best Welsh large foundry coke and was destined for Buenos Aires under a contract recently placed by Moxey, Savon & Co., Ltd., Buenos Aires. Normally coke is shipped only in small quantities. To ensure the shipment of the coke in the best possible condition, the Docks and Inland Waterways Executive made available the escalator loading device which is designed to obviate the breakage of coal when tipped from wagons into the holds of the ships. This was used to commence the loading in each hold.

SHIPBUILDING AT NEWPORT.—The new shipyard under construction at Newport for the Atlantic Shipbuilding Co., Ltd., has received its first order. It is for two ships for the Quebec and Ontario Transportation Co., to be used for carrying wood pulp from Canada to the United States. The ships, built to American Bureau of Shipping classification, will be 252 ft. long, with a beam of 43 ft. Designers are at work on the plans for the ships in London, and, when new offices are completed on the shipyard site, the whole staff will move to Newport.

OLD-TYPE TIN-PLATE WORKS.—Rumours that the old-type tin-plate works at Gorseinon and Pontardawe, now on a care and maintenance basis, were certain to re-open next month have been denied by Mr. Godfrey Walker, information officer to the Steel Company of Wales, who has stated that the company had always said they would re-open the works if and when possible, but no date could be estimated. There had been a slight improvement in demand for tin-plates, and, if this continued and if other factors such as labour were suitable, the works might be re-opened.

FAIRWOOD COMMON AERODROME, SWANSEA.—For the third time, an application by Swansea Borough Council, seeking planning permission for the retention of Fairwood Common aerodrome as a municipal airport for civilian use, has been deferred by the Glamorgan County Planning Committee. Objection to the scheme has come from the Gower Association of Parish Councils.

PROPOSED TELEVISION STATION IN DARTMOOR NATIONAL PARK.—Mr. Harold Macmillan, Minister of Housing and Local Government has appointed Mr. H. G. Warren, O.B.E., A.R.I.B.A., M.T.P.I., to hold an inquiry into the proposal of the British Broadcasting Corporation to erect a television station on North Hessary Tor, in the Dartmoor National Park. The inquiry, which is to commence on Tuesday, September 29, will be held at the Castle, Exeter.

CONTRACTS.

Contracts placed by the British Electricity Authority, during July, for power-station transforming-station, and transmission-line equipment, amounted, in the aggregate, to 10,290,453*l*. The principal orders included: for Acton Lane "B" power station, Willesden, two 240,000 lb. per hour boilers, with MITCHELL ENGINEERING, LTD.; for Marchwood power station, Southampton, structural steelwork, with ALEX FINDLAY & CO., LTD., and one 530,000 lb. per hour boiler, with JOHN THOMPSON WATER TUBE BOILERS, LTD.; for East Yelland power station, near Barnstaple, two 30,000-kW turbo-generators and feed-heating plants, with C. A. PARSONS & CO., LTD.; for Tilbury power station, three 60,000-kW turbo-generators, condensing and feed-heating plants, with C. A. PARSONS & CO., LTD., and piling for foundations for the second half of the station, with HOLLOWAY BROS. (LONDON), LTD.; for Castle Donington power station, near Derby, 275-kV switchgear, with the BRITISH THOMSON-HOUSTON CO., LTD.; for Nottingham power station, two 300,000 lb. per hour boilers and ancillary equipment, with MITCHELL ENGINEERING, LTD.; for Wakefield power station, high-pressure steam feed pipework and valves, with ATTON & CO., LTD.; for Stella North power station, near Newcastle-upon-Tyne, two 60,000-kW turbo-generators and condensing and feed-heating plants, with C. A. PARSONS & CO., LTD.; for Huncoat power station, Accrington, one cooling tower, with FILM COOLING TOWERS (1925), LTD., and foundations for a turbo-generator set and boiler, with J. JARVIS & SONS, LTD.; for Barony power station, Ayr, preliminary civil-engineering works, with JOHN LAING & SONS, LTD.; for Clyde's Mill power station, Glasgow, pipework, valves, steam receivers and tanks, with STEWARTS AND LLOYDS LTD.; for Hartley substation, Kent, 132-kV isolators and connections, with the ENGLISH ELECTRIC CO., LTD.; for Harrow substation, Middlesex, 90-MVA 132/33-kV transformers, with the ENGLISH ELECTRIC CO., LTD.; 132-kV, 22-kV, and auxiliary cables from Woolwich to Eltham, London, with W. T. GLOVER & CO., LTD.; a 132-kV double-circuit line from Andover, Hampshire, to Thatcham, Berkshire, with PIRELLI-GENERAL CABLE WORKS, LTD.; 132-kV overhead transmission lines from Lancaster to Quernmore and from Blackburn to Quernmore, with BRITISH INSULATED CALLENDER'S CONSTRUCTION CO., LTD.; and 132-kV cables from Cambuslang to Clyde's Mill, with PIRELLI-GENERAL CABLE WORKS, LTD.

HUNTING AEROSURVEYS LTD., 29, Old Bond-street, London, W.1, have obtained a contract worth over a quarter of a million dollars for aerial photography and mapping in the Hashemite Kingdom of Jordan. The survey will cover approximately 85 per cent. of Jordan.

MELVILLE, DUNDAS AND WHITSON, LTD., 21, Blythswood-square, Glasgow, C.2, have obtained a contract from the Corporation of Glasgow, valued at 40,000*l*., for the building of a foot-bridge over the River Clyde, at Polmadie.

WILLIAM DENNY & BROS., LTD., Dumbarton, have received an order from British Railways for a combined passenger and vehicular ferry vessel for the Kyle of Lochalsh-Kyleakin (Skye) service. The new ship will be similar to the 53-ton Portree, launched in 1951 at Dumbarton for the same service. She will have covered accommodation for 50 passengers and space for the carriage of four motor cars. A turntable will be fitted to facilitate loading and unloading.

CROMPTON PARKINSON, LTD., Crompton House, Aldwych, London, W.C.2, are to supply to the U.S.S.R. 200 km. of power cable, valued at approximately 500,000*l*. The delivery of the cable will begin in September and will be completed by the end of the present year.

THE EXPRESS LIFT CO., LTD., Northampton, are to manufacture, supply, test and maintain 100 electric passenger lifts at housing estates of the London County Council. The amount of the tender was 195,880*l*.

JOHN FOWLER & CO. (LEEDS) LTD., Leeds, have received an order from the Burmese Purchasing Commission, worth 85,000*l*., for Fowler 150-b.h.p. Challenger 4 Diesel crawler tractors. The tractors will be distributed through the firm's associate company, Marshall's (India), Ltd.

GEORGE BROWN & CO. (MARINE) LTD., Greenock, and A. and J. INGLIS, LTD., Pointhouse, Glasgow, are each to build a cargo motorship of 1,200 tons deadweight carrying capacity for the Belfast-Liverpool service of the Belfast Steamship Co., Ltd. Sulzer-type machinery for both vessels will be provided by GEORGE CLARK (1938), LTD., Sunderland.

LEYLAND MOTORS LTD., Leyland, Lancashire, have received an order from Jamaican Omnibus Services Ltd., for 21 Royal Tiger 15 ft. 7 in. wheelbase and 15 Royal Tiger 20 ft. 4 in. wheelbase omnibus chassis, all with underfloor Diesel engines.

ETHYL SILICATE FOR FOUNDRY USE.

A POLYMERISED ethyl silicate which acts as a bond when mixed with refractories and improves the life of furnace linings and the performance of moulds has been placed on the market by Monsanto Chemicals, Limited, Victoria Station House, London, S.W.1. The silicate, to which the name Silester O has been given, is a slightly turbid liquid having a specific gravity of from 1·05 to 1·07 and a silica content of from 40 to 43 per cent. When the substance is hydrolised by the addition of water in the presence of a catalyst, a chemical reaction sets in, on completion of which an adhesive siliceous dispersion is formed. If the hydrolised solution is then mixed with a refractory or a granular filler, or is applied to a porous surface, the substance becomes bonded with this siliceous dispersion. When heated to a temperature above 750 deg. C., the silica is reduced to a finely divided state and this provides a bond, the strength of which can be adjusted to a large extent to suit the requirements of a particular application.

The polymerised ethyl silicate is recommended for use as a bond for investment moulds and as a wash for sand moulds to improve the finish of castings from high-nickel content alloys. Moreover rammed monolithic linings of zircon with Silester bond are stated to give four times the life of conventional furnace linings, while washes can also be used to improve the life of lower-grade furnace linings. Furthermore, the new silicate is recommended for use in connection with permanent ceramic moulds, feeder blocks in gravity dies, precision piece moulds, high-grade refractories and certain types of low-loss electrical insulators.

It is emphasised that the silicate is a perfectly stable liquid when kept in air-tight containers and that, whereas methyl silicate vapours and liquid may cause severe eye injury, no such effect has been observed with ethyl silicate. Furthermore, the new liquid apparently has shown no characteristics which might produce silicosis and, provided normal ventilation precautions are taken, no danger should arise from inhalation of the vapours. Finally, the liquid has no corrosive action on the skin and is easily removed by washing, first with alcohol and then with soap and water.

SIGNING OF IRISH RAILWAY AGREEMENT.—The formal agreement giving effect to the decision of the Governments of Northern Ireland and the Irish Republic to acquire jointly the Great Northern Railway (Ireland), as mentioned on page 98, *ante*, was signed in Belfast on August 10. This action brought to an end negotiations which had been in progress for nearly three years. The Great Northern Railway Board, which has been formed to administer the railway, will comprise five representatives from Northern Ireland and five from the Irish Republic. The senior representatives of the two countries will act as chairman and vice-chairman, respectively, changing offices at the end of each year. The Board will commence their operations on September 1, next.

COMPETITION IN CRAFTSMANSHIP AND DRAUGHTSMANSHIP.—Nearly 100 entries were received by the Gauge and Tool Makers' Association, Standbrook House, Old Bond-street, London, W.1, for their third competition in craftsmanship and draughtsmanship. In the craftsmanship section, the independent adjudicating panel has awarded prizes to P. F. Slade, Arnott and Harrison, Ltd., London; W. J. Boulton, J. H. Edridge and K. R. Shaw, B.I.P. Tools Ltd., Birmingham; J. R. Cooper and R. J. Weake, Brooke Tool Manufacturing Co., Ltd., Birmingham; C. M. Boylan and W. J. Chandler, Coventry Gauge and Tool Co., Ltd., Coventry; J. H. Charlesworth, Hall and Pickles, Ltd., Manchester; and A. J. Weedon, Thomas Mercer, Ltd., St. Albans. Prizes for draughtsmanship were awarded to P. I. Ealing and D. H. Faiers, Arnott and Harrison, Ltd., London; D. Hubbard, Brooke Tool Manufacturing Co., Ltd., Birmingham; F. E. Needham, Coventry Gauge and Tool Co., Ltd., Coventry; and R. Hordern, John A. Smith, Ltd., Wolverhampton. The competition was open to apprentices and learners employed by firms belonging to the Association, and the winning entries will be displayed at the forthcoming Engineering, Marine and Welding Exhibition at Olympia, London, W.14.

PERSONAL.

WHEN the Ministry of Transport and the Ministry of Civil Aviation are amalgamated in October, SIR ARNOLD OVERTON, K.C.B., K.C.M.G., M.C., having reached the age of 60, will retire from the public service. SIR GILMOUR JENKINS, K.C.B., K.B.E., M.C., will be the Permanent Secretary of the combined Ministry.

MR. H. NORMAN G. ALLEN has been re-elected chairman of Council of the British Internal Combustion Engine Research Association, 111-112, Buckingham-avenue, Slough, Buckinghamshire, for the current year.

MR. J. C. K. SHIPP, B.Sc., A.F.R.Ae.S., M.I.Ae.S. has joined the English Electric Co. Ltd., Queen's House, Kingsway, London, W.C.2, from the Ministry of Supply, to become the company's aviation representative in the United States.

MR. G. C. R. ELEY, C.B.E., has been elected a director and deputy chairman of the Brush Electrical Engineering Co., Ltd. MAJOR N. E. WEBSTER, O.B.E., M.C., M.I.Min.E., President-elect of the Institution of Mining Engineers, has also joined the board.

MR. H. B. MCAUSLAN has been appointed resident representative of the Brush Group in India, Pakistan and Burma. MR. A. L. CRAMB, M.I.E.E., has been appointed manager, in India, of the Brush Electrical Engineering Co., Ltd. He remains a director of Brush Export Ltd.

MR. ROBERT W. ASQUITH, MR. H. J. D. KEARNS, MR. W. J. MORGAN, M.B.E., and MR. R. D. G. RYDER, who are representatives of the manufacturers' section of the Machine Tool Trades Association, Victoria House, Southampton-row, London, W.C.1, have been elected delegates to the European Committee for Co-operation of the Machine Tool Industries in connection with the Third European Machine Tool Exhibition, to be held in Brussels from September 4 to 13.

MR. ROBERT ONIONS, A.M.I.Mech.E., 44, Grenview Boulevard South, Toronto, 18, has been appointed resident factory representative, in Canada, of W. H. Dorman & Co., Ltd., Stafford. To act as distributors for the firm, A. B. WING, LTD., 1383, Hornby-street, Vancouver, 1, have been appointed for British Colombia and Alberta; THE DALE EQUIPMENT CO., LTD., 1524, Erin-street, Winnipeg, for Manitoba; MODERN MACHINERY, LTD., 120, Fourth-street West, Quebec, for Quebec; and CONTRACTORS MACHINERY AND EQUIPMENT, LTD., 194, Barton-street East, Hamilton, for Ontario.

MR. A. E. BAGG has relinquished his position with Industrial Guarding Equipment Ltd., to take up the appointment of managing director of Press Guards Ltd., Farm-street, Birmingham.

MR. F. WALLIS, founder of Glynwed Tubes Ltd., Bilston, Staffordshire, has retired from the chairmanship, but is remaining on the board. MR. W. G. A. RUSSELL, has been elected a director and appointed chairman of the company. MR. W. H. B. HATTON has also retired from the board, and MR. N. FORBES, the secretary of the company, has been elected to fill the vacancy.

THE HARRY FERGUSON COMPANIES and the MASSEY HARRIS CO. LTD. have agreed to amalgamate and to operate under the name of MASSEY-HARRIS-FERGUSON Ltd., for the production of agricultural machinery.

TYNE PLYWOOD WORKS LTD., Willington Quay, Wallsend-on-Tyne, have changed their name to TYNE PLYWOOD (HOLDINGS) LTD. The plywood manufacturing operations, previously carried on by the firm, will in future be conducted by a new company named TYNE TIMBER AND VENEERS LTD. This amplifies our previous reference, on page 175, *ante*.

COCKBURNS LTD. Clydesdale Engineering Works, Cardonald, Glasgow, S.W.2, and North Shields, have opened a London office at 175, Piccadilly, W.1, under the management of CAPTAIN (E) G. R. COOK, O.B.E., D.S.C., R.N. (ret.).

WILLIAM JESSOP & SONS LTD. and J. J. SAVILLE & CO. LTD. have opened a new area office at York House, 12, York-street, Manchester, 2 (Telephone: Central 9184), to direct the selling activities of their Lancashire and Yorkshire territories. The office is under the control of MR. H. CARR.

F. J. EDWARDS LTD., 359-361, Euston-road, London, N.W.1, have formed a new company, F. J. EDWARDS (CANADA) LTD., 16, Watsons-drive, Etobicoke, Toronto, 18, Ontario. The President is MR. H. A. JOHNSON, the vice-president, MR. G. M. HAYWARD, and the resident managing director, MR. J. L. HALL. To act as main distributors, SIMPSON MACHINERY CO. LTD., 2180, Wilson-avenue, Montreal, 28, have been appointed for Quebec; T. S. TAYLOR MACHINERY CO. LTD., 187, Bannatyne-avenue E., Winnipeg, for Manitoba; WILKINSON & MCLEAN LTD., 10235, 103rd-street, Edmonton, and 1215, 9th-avenue W., Calgary, for Alberta; and B.C. EQUIPMENT CO. LTD., 551, Howe-street, Vancouver, for British Columbia.

MANIPULATION OF SEAMLESS TUBES.

(*For Description, see Page* 225.)

FIG. 7. DRAWING SMALL TUBES THROUGH DIAMOND DIES.

FIG. 8. STRAIGHTENING SMALL TUBE.

WATER SUPPLY TO EAST GLASGOW.

THE recent decision by Glasgow Corporation to construct a water-supply scheme costing approximately 219,000*l.* is necessitated by housing developments on ground which was brought within the City Boundary in 1937. Ten areas in all were acquired at various points surrounding the previous boundary. One of the last of these to be developed for housing purposes is in the east of the city in what was formerly the County of Lanarkshire. The area is at present agricultural, and the water supplies are provided by Lanark County Council and the Airdrie and Coatbridge Water Board. They are supplied principally through very small mains to widely scattered farms and dwelling houses. On about 1,000 acres of this land Glasgow Corporation propose to construct the Easterhouse Township. About 400 acres will be reserved for open space, some of it being unsuitable at present for building owing to old coal-mine workings. Under the Glasgow Corporation Boundaries Extension Act of 1937, Glasgow was not required to take over the water supply to the area until after 1947, when two years' notice to the water-supply authorities concerned was to be given.

Water supply to the eastern area of the city has always been problematical owing to the high level of the ground and to its extreme distance from the sources of supply, which lie principally to the north-west. Since the war, however, a new 36-in. diameter main, 14 miles long and costing 800,000*l.*, has been laid from the service reservoirs at Milngavie, effecting a considerable improvement. This main skirts the east of the supply area and will form the eastern half of a ring-main system. A quantity of 15 million gallons of water per day is pumped through this east main, from the new pumping station at Buchley, into several service reservoirs, the largest of which is a new six-million gallon concrete structure at Ruchazie. Easterhouse Township will require about three million gallons per day and this supply will be taken from the new east main. A new reinforced-concrete service reservoir of three million gallons capacity, divided in the centre, will be constructed at Garthamlock. It will have a top water level of 345 ft. above O.D., which is the highest level to which water can be pumped from Buchley. A new pumping station at Garthamlock will be constructed and will pump water from this new reservoir to a water tower to be built on an adjacent site with a top water level of 463 ft. above O.D. Considerable development is already taking place in the eastern area of the city and some housing schemes already started will be supplied from this new system.

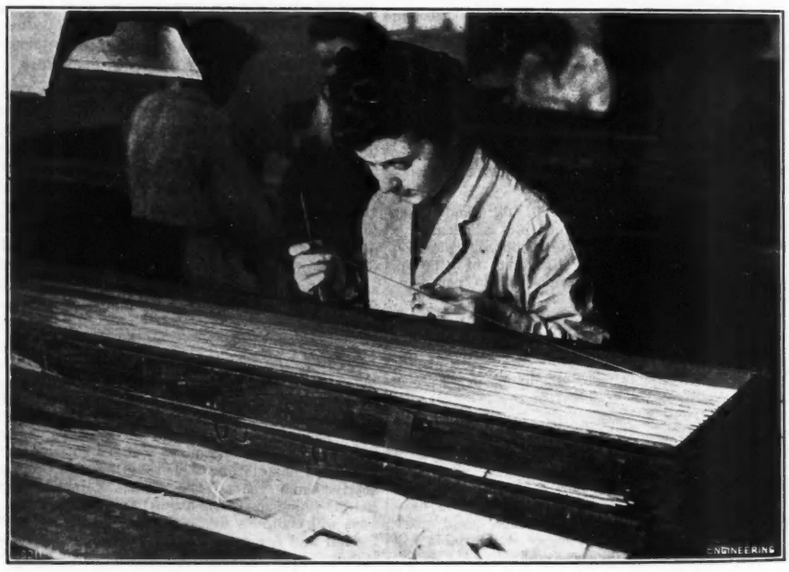


FIG. 9. FINAL INSPECTION OF SMALL TUBES.

It is intended, at present, to construct only one half of the three-million gallon reservoir, and to install only one of an eventual four pumps, each capable of pumping one million gallons per day. In the first place one pump only will deliver from a 24-in. main to be laid to supply the new reservoir direct into the distribution piping system at Garthamlock and other housing areas. As development proceeds and the half-reservoir and water tower are constructed, two pumps will pump from the reservoir to the water tower, a third pump being installed for standy-by purposes. Eventually, should the whole 1,000 acres of the Easterhouse Township be developed, a fourth pump will be installed, allowing for three operational pumps and one stand-by.

The estimated costs of this work are as follow: 24-in. rising main from the new east main to the new ground-level service reservoir, 21,000*l.*; ground-level service reservoir, three million gallons, 90,000*l.*; pumping station, with machinery, 23,000*l.*; elevated water tower, one million gallons capacity, 85,000*l.*; total, 219,000*l.* As development layouts are not yet available, this figure is exclusive of the cost of distribution piping. The whole development is expected to be completed by 1959 and the works are designed to be capable of meeting all future requirements within the area of the city. The design and construction of the works are being carried out under the supervision of Mr. Stanley D. Canvin, M.I.C.E., chief engineer and general manager of the City of Glasgow Water Department.

"THE ENGINEERING INDUSTRIES OF SHEFFIELD": ERRATUM.—On page 59, *ante*, the photograph reproduced as Fig. 18 in the abridged version of Mr. M. A. Fiennes's paper, delivered before the Institution of Mechanical Engineers at their Summer meeting in Sheffield on July 1, was acknowledged to Edgar Allen & Co., Ltd. We have since been informed that the acknowledgment should have been made to Sanderson Bros. & Newbould, Ltd.

ENGINEERING

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

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The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 10*s.* for the first four lines or under, and 2*s.* 6*d.* per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 30*s.* per inch. If use is made of a box number the extra charge is 1*s.* per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33⅓ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be received not later than first post Monday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received 16 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

CONTENTS.

	PAGE
The Manufacture and Manipulation of Seamless Tubes: Messrs. Accles and Pollock, Limited.—III (*Illus.*)	225
Literature.—Photometry. Trusts and Foundations. La Mécanique Ondulatoire. The Science of Petroleum, Vol. V, Part II: Synthetic Products of Petroleum	227
Design Aid for Shrink-Fit Calculations (*Illus.*)	228
Analysis of Rigid Frames by an Electronic Digital Computer (*Illus.*)	230
Variable Gauge Diesel-Electric Locomotives (*Illus.*)	233
Land Reclamation in Northern India and Pakistan	233
Navigation Light for the "Ambrose" Lightship (*Illus.*)	234
Hydraulic Copying Attachment for Lathes (*Illus.*)	235
Automatic-Control Equipment for Diesel Engines	235
Kelvin Hughes Long-Range Radar Equipment for Ships (*Illus.*)	236
Oxygen Generating Plant for Industrial and Mobile Use (*Illus.*)	237
Notes from the Industrial Centres	238
Contracts	239
Ethyl Silicate for Foundry Use	239
Personal	239
Water Supply to East Glasgow	240
Radio Research	241
Coal-Mine Accidents	242
Notes	243
Letter to the Editor.—Problems of Fluid-Flow Measuring Devices	244
Obituary.—Sir Bernard Darley, C.I.E. Dr. G. L. Kelley	244
The Measurement of Wave Heights in the Model of Table Bay Harbour (*Illus.*)	245
Wrought Nickel-Molybdenum Alloys	248
Launches and Trial Trips	248
Labour Notes	248
Six-Spindle Automatic for 1-in. Bars (*Illus.*)	249
Petroleum Storage and Distribution Depot (*Illus.*)	250
Lightweight Supercharged Marine Diesel Engine (*Illus.*)	251
The Shell Moulding Process	251
High-Speed Milling and Grease-Producing Plant (*Illus.*)	253
Annuals and Reference Books	253
Single-Deck High-Speed Tramcar for Leeds (*Illus.*)	254
British Standard Specification	254
Cold-Air Unit for Aircraft Cabins (*Illus.*)	255
Notes on New Books	255
Geared Inclinable Press (*Illus.*)	256
Books Received	256

ENGINEERING

FRIDAY, AUGUST 21, 1953.

VOL. 176. No. 4569.

RADIO RESEARCH.

THE history of engineering contains many examples of the way in which progress has been achieved with the dual assistance of empiricism (that is, experience and experiment) and pure speculation or intuition. In the case of radio communication, for instance, many of the earlier developments were the result of work in the laboratory or the field, and were secured without any profound knowledge of the underlying physical principles. In this contest between practice and theory the latter was also handicapped by the advances in application which occurred during the 1914-18 war; and this gap had been only partly filled when hostilities broke out in 1939. For the next six years practice was again well in the ascendant; and developments took place, which have still not been fully recorded and the theoretical bases of which have not been fully enunciated. It is the duty of the Radio Research Board, the report* of which for 1952 was published recently, to restore the balance between the two sides of this branch of engineering by carrying out investigations of a fundamental nature, so that not only shall the scientific reasons for what has been done be clarified, but a foundation be laid for the future development of all forms of radio and communications technique.

* *Radio Research*, 1952. H.M. Stationery Office, York House, Kingsway, London, W.C.2. [Price 2*s.* net.]

Such work is obviously of a long-term character, from much of which immediate results cannot be expected. The Board have, however, adopted the wise policy of publishing articles either in the technical Press or through more official channels; and from these, in combination with the information given in the annual report, it is possible to gain some idea of what is being done. From these sources it appears that the major part of the programme of research during the year under review, as it has been in the recent past, was concerned directly with wave-propagation. There has been, it may be gathered, some mild criticism of this policy. Nevertheless, it has been decided that the appropriate investigations should not be curtailed, for the sound reason that the efficient operation of any radio system depends on a knowledge of the properties and influences of the medium between the transmitting and receiving aerials. In fact, the diverse applications of radio waves over an extremely wide band of frequencies produce many problems which demand examination, and the solution of which may well assist practical developments. Such work, therefore, should not be discouraged.

As an example of what is being done in this direction, mention may be made of the research which has been undertaken into the behaviour of the ionosphere with a view to obtaining data from which the operation of high-frequency communication systems can be efficiently planned. Seven laboratories, two of which—one at Khartoum and the other at Port Lockroy in the Falkland Island Dependencies—were brought into use during the year for this purpose, while 60 more are maintained in other countries, with which, it may be assumed, close contact has been established. At these establishments the effects of the ionosphere on vertically-directed transmission are observed; and forecasts are prepared of its behaviour for the more horizontal directions common in practical commercial transmission. These data, in turn, permit the best frequency bands for use for particular purposes to be determined. A direct method of examining the behaviour of the ionosphere at oblique incidence is being developed, which enables signals propagated by way of the ionosphere and reflected back to the transmitting point from regions on the earth, several thousand kilometres away, to be picked up and measured. The skip distances observed in this way agree with the calculated values obtained from vertical-incidence observations immediately below the reflecting point in the ionosphere. The practical value of this technique is that it may enable propagation conditions to be studied at a distance, so supplementing the information obtained from the widely-separated observatories.

The investigations in the field of high-frequency direction-finding had the useful result of providing a greater understanding of the irregularities in the ionosphere and how they lead to the introduction of directional errors. In this connection, mention may be made of the opportunities offered by the total eclipses of the sun which occurred in February and August, 1952, to observe the effects on radio communications. These effects are similar to those which take place during a 24-hour period, owing to the succession of day and night, with the important difference that the whole process is condensed into a comparatively short period of time. In addition, there are other important differences in the observed phenomena, which enable information to be gained during eclipses such as is not easily available at normal times. A more complete knowledge of the mechanisms responsible for each ionosphere layer which might be thus obtainable would be of considerable practical value, since forecasts of future ionospheric behaviour, which are at present made by empirical methods, could be given a more theoretical basis. It might then become unnecessary to maintain an extensive network of ionospheric observations.

Turning to another branch of the work, investigations are in progress on two problems which are important when radio waves in the 40 to 600 megacycle band are used. One of these concerns the effects on propagation of varying refraction in the troposphere, to investigate which observations have been made of the field strength produced over distances of 150 to 250 km. from television transmitters. The results of these measurements, with other similar data supplied by the British Broadcasting Corporation and the Post Office, have been used to prepare generalised curves of field strength which, it is hoped, will be of assistance in planning television and other very high frequency broadcasting. The other problem is the effect on propagation at these frequencies of irregularities in the earth's surface. This has been studied by making field-strength measurements at frequencies of 100 and 600 megacycles over transmission paths at distances up to about 50 km.

Measurements have also been made of the speed of the ground wave at low frequencies—or more specifically, of the phase of the signal and its rate of change with distance—a matter which is of importance in the operation of some navigational aids. This speed is dependent upon the ground conductivity and thus on its geological structure. Phase changes along paths covering different structures have therefore been measured and the results, in general, confirm theoretical expectations. The experience gained has been used to develop a new method of measurement for examining the important case of transmission across a coast line.

A study of contemporary literature in more than one field will indicate that the subject of radio noise, whether originating within or outside a receiver, is of some importance. The Radio Research Board have, however, mainly confined their activities in this field to investigating the strength of the atmospheric noise which is caused by lightning flashes. This investigation has been based on observations which are made regularly at a number of stations throughout the world, and an analysis of them has enabled graphs to be prepared for each season of the year. These graphs show the amount of noise observed in various localities at a given time of day on selected frequencies from 2·5 to 20 megacycles, and thus enable information to be collected from which it will be possible for more accurate predictions of atmospheric noise levels to be made. Work on noise originating in the receiver itself has included the study of the spectrum of point-contact germanium rectifiers over a frequency range of 0·1 cycles to 10 megacycles. It has been found that there are at least three separate components which determine the shape of the spectrum. These results, together with an experimental investigation of other characteristics of germanium triodes, are being examined in relation to existing theories. Research is also in progress on the connection between the structure of certain inorganic compounds and their ferromagnetic and ferroelectric properties.

Although much of this work may appear to be rather remote from every-day practice, the small number of investigators who practice under the direction of Dr. R. L. Smith-Rose live in no ivory tower. In fact, they have had for some time to carry out their duties in temporary buildings at Slough, supplemented by certain accommodation at the National Physical Laboratory. This dispersal cannot make for efficiency, and may explain the difficulty of obtaining qualified research workers. It is satisfactory to learn, therefore, that the construction of permanent buildings at Slough is to be begun. It is to be hoped that their completion will not be long delayed and that the work which, since the end of the war, has been carried on under the chairmanship of Sir Stanley Angwin, will be continued equally profitably under Sir Noel Ashbridge.

COAL-MINE ACCIDENTS.

CURVES covering the period from 1931 to 1951 show a gradual fall in the rate of fatal accidents per ton of output in British coal mines and also in the rate of reportable injury; a person is "reportably injured" if subjected to fracture or dislocation of a limb, or is seriously injured by explosion, electric shock or overwinding. The curve representing deaths is very irregular and contains high peaks; that relating to cases of injury is reasonably smooth. This is a matter for satisfaction, as showing long-term improvement in the introduction of safety measures and the extent to which they are observed. The improvement is indicated by the curve for injuries, which may be taken as approximately representing the results achieved in normal, every-day working. The curve for deaths may, in any individual year, be greatly distorted in an upward direction by a single serious mine explosion.

The figures for the year 1951 clearly illustrate the growing improvement which is being achieved. Although the record for that year was marred by an explosion of firedamp and coal dust at Easington Colliery, Durham, which caused the death of 83 persons, none the less the rates both of deaths and cases of serious injury were the lowest ever achieved. The figures are given in the latest report* of the Chief Inspector of Mines. This report, which has just been published, has appeared six months later in the year than did the corresponding report for the year 1950. The delay has possibly been due to the administrative changes associated with the retirement of Sir Andrew M. Bryan from the post of Chief Inspector in 1951 and the appointment of Mr. H. C. W. Roberts in his stead.

Although the mines inspectors are primarily concerned with safety measures and not with total output, it must be gratifying to them that the output curve has risen almost in a straight line since 1945, although the figure for 1937 is still far from being equalled. Moreover, the downward slopes of the curves of fatal accident and injury have both become steeper since 1945. That year marked the nadir of output during the last twenty years. The accident curves do not throw any light on the deplorable steady fall in output from 1937 to 1945 or on the steady rise since this latter year. These factors are outside the subject under discussion but it is of some interest to note that the fall and rise in output do not appear to have had any effect on the rate of accident per ton of coal won.

The spectacular colliery disasters to which public attention is directed are almost all caused by firedamp, or coal-dust explosions, but actually the death and injury rates due to these causes lie far below those due to falls of ground, which in every year since 1931 have caused more deaths and cases of injury than any other agent. This applies even in years marked by serious explosions. The fact that accident rates due to falls of ground are decreasing may be attributed both to the introduction of new methods of support and the improvement of old ones, and also to increasing care exercised by the workpeople concerned. The support of the roof at the working face, or at roadheads, is in every individual case a local problem which demands both foresight and knowledge on the part of those responsible for its solution. Part of the improvement which has been achieved is no doubt due to the coal-face training schemes which have been put into operation, but that there is still much to do in educating the men to have proper regard for their own safety is made evident by frequent statements in the report to the effect that, for instance, "the supports, temporary or permanent, were not set early enough."

In view of new methods of working which are being introduced in mines—in particular, the use of armoured conveyors—the question of roof support is being studied by the National Coal Board, to some extent in collaboration with the mines inspectorate. The conveyors are loaded by hand or power and are advanced without being dismantled, so that any props set on the face side have to be taken out. Various new types of prop and bar, mainly of Continental origin, are being introduced, but the report states that in spite of the high claims made for their effectiveness there is "still a good deal to learn about them and about their operation under practical conditions."

Attention is being paid to the question of roof support by bolting, and some experimental work has been carried out by the Safety in Mines Research Establishment. Interest in this technique has been revived by the report of the Anglo-American Productivity Team which dealt with the coal-mining industry. A method of roof support which eliminates props and pillars is attractive, but the physical conditions in British and American mines are so different that the practice of one is not necessarily suitable for the other. The Productivity Team recommended that "a survey should be made, based on American experience, with the object of introducing roof bolting in Britain wherever conditions allow." The work which has been carried out by the Research Establishment, in sandy shale and soft limestone, showed that "provided the ground in which the anchorage is made is hard and the bolt is properly fixed, both expansion bolts and wedge bolts can give quite satisfactory resistance." Much depends on the method of fixing; the wedge bolts, tightened by pneumatic hammer, and the expansion bolts tightened by turning the nut at the end of the bolt, gave resistances of 10 tons with little yield. Neither, however, was reliable with other methods of fixing. Further work is to be done in softer ground and to assess the influence of water used in drilling.

Haulage is the second main cause of accidents, and in the average year results in more deaths and cases of injury than any other agent except falls of ground. In years, however, marked by a serious explosion or fire, haulage accidents take the third place. Accidents connected with the use of conveyors are included under haulage accidents, but tub haulage is responsible for far more cases of death and injury than are conveyors. In both cases, an important proportion of the accidents were due to defective maintenance. One of the satisfactory features of the accident returns over many years has been the very few attributable to shaft winding. No persons have been killed by overwinding since 1943. Most of the accidents which do occur are due to mistaken signals or premature movement of the winding engine. In general, it is clear that shaft-winding arrangements are maintained in good condition and that inspections are carried out with care. As compared with a coal cutter in a remote heading, the shaft-winding plant is under immediate observation by many officials.

Underground locomotives increased from 383 to 450 during the year. Sixty were of the electric-battery type and 390 were driven by Diesel engines of between about 25 and 100 h.p. One or two mines used 100-h.p. locomotives in tandem. The Chief Inspector praises the two locomotive builders who produced prototype Diesel designs with a driver's seat and controls at each end so that, irrespective of the direction of motion, the driver has a clear view ahead without having to lean out. Other details of locomotive design, small in themselves but affecting the safety of the men, are also dealt with in the report. It is only by such steady and continuous attention to detail that injuries and deaths are minimised. In that way, for example, electricity in mines has been rendered notably safe; it was directly responsible for only three fatal accidents in 1951.

* *Report of H.M. Chief Inspector of Mines under the Coal Mines Act, 1911, for the Year 1951.* H.M. Stationery Office. [Price 2s. net.]

NOTES.

THE INSTITUTION OF MECHANICAL ENGINEERS: CLAYTON AND MANVILLE AWARDS.

THE Council of the Institution of Mechanical Engineers, under the terms of the Clayton and Manville bequests, have made the following awards for 1953, to enable the recipients to obtain special experience, pursue post-graduate studies, or carry out research in mechanical engineering. The Manville awards have been made to applicants whose primary interest is in automobile engineering. The total value of all the awards for 1953 is approximately 5,800*l*. Ten Clayton Fellowships have been awarded as follows: to Mr. F. J. Bayley, M.Sc., of Monkseaton, Northumberland, for research on heat transfer, especially in the cooling of gas-turbine rotor blades; to Mr. R. J. Beale, B.Sc. (Eng.), of Bramley, Surrey, for research on heat transfer between a cylinder and a liquid flowing across it; to Mr. D. E. Evans, B.Sc. (Eng.), of Stanmore, Middlesex, for an investigation into the milling of fine powders; to Mr. E. J. Forster, B.Sc. (Eng.), of Bromley, Kent, for research on heat radiation from pulverised-coal flames; to Mr. J. C. Gordon, of Hamilton, Lanarkshire, to enable him to visit steelworks in France, Germany, and the United States; to Mr. N. H. Ineson, B.E., of Western Australia, now resident in Newcastle-on-Tyne, for visits to United Kingdom makers of cranes, etc.; to Mr. G. D. Jordan, M.Eng., of Sheffield, for visits to steelworks in Britain and the United States, to study lubrication; to Mr. D. J. Myles, B.Sc. (Eng.), of Arbroath, Angus, to continue an investigation into the distribution of pressure and velocity in a rotodynamic pump; to Mr. J. R. Plant, B.Sc.(Eng.), of Burnley, Lancashire, for research on the shear strength of soils; and to Mr. S. Soundranayagam, B.Sc. (Eng.), of Ceylon, now in London, for research on three-dimensional losses in a cascade of aerofoils. In addition, Clayton Grants have been made to Mr. I. Mansell, of High Green, near Sheffield, for a course of training with United States firms who specialise in heavy construction equipment; to Mr. J. L. Raynes, B.Sc. (Eng.), of Bournemouth, for a year's post-graduate course in aeronautics; to Mr. A. Sadler, M.Sc., of Bishop's Cleeve, Gloucestershire, for visits to United States firms producing automatic-control equipment; and to Mr. A. Shelton, B.Sc. (Eng.), of Hayes End, Middlesex, for research on plastically-deformed materials. The Manville Fellowship for 1953 has been awarded to Mr. J. M. Hamilton, B.E., of Hornsby, New South Wales, for visits to makers and operators of public-service vehicles, to study current braking practice; and a Manville Grant to Mr. J. G. Giles, B.Sc. (Eng.), of Sevenoaks, Kent, for the design and construction of a hydraulic transmission for motor vehicles. All of the recipients of the awards belong to the Institution of Mechanical Engineers, four being associate-members, ten graduates, and the remaining two, students.

ENGINEERING EXPORTS.

In the current issue of *Bulletin for Industry*, the monthly review prepared by the Information Division of the Treasury, the engineering exports of the United Kingdom, the United States, and Germany are compared. The general conclusion is that "we may have lost a little ground; and there is no reason to suppose that at the moment our engineering exports are rising faster than those of the other two countries. Some other sterling area countries have recently eased their import restrictions, and this may help us to recover our 1951 share of world trade." The United Kingdom engineering industries have in recent years been exporting about one-third of their output—a figure which is much higher than before the war and is above the proportion for all manufacturing industry. Engineering goods were 26 per cent. of U.K. exports in 1938; 38 per cent. in 1948; 41 per cent. in 1952. Cars and commercial vehicles have shown an exceptionally sharp increase, their value increasing 14 times from 1938 to 1950. For the first five months of 1953 all the main groups of engineering exports showed a fall in value; for engineering products as a whole the fall is to about 3 per cent. below the 1952 average. Changes in prices of metals and products are partly responsible, but with many kinds of engineering goods there have also been significant falls in the quantity exported. Reduced exports of agricultural and textile machinery, as well as of prime movers, are common to the three countries, though agricultural machinery exports recovered quite sharply from the first to the second quarter of this year. Some export rises, too, are common: mechanical-handling equipment, machine tools, and electrical machinery and apparatus. The figures also suggest some shifts in trade. Thus, office machinery exports have risen for the United Kingdom and Germany, but have fallen for the United States. British paper-machinery exports have risen, while those of the other two countries have fallen. The machine-tool figures reflect the trade in defence machine tools, which in the past two years this country has bought from the United States and the Continent. Over this period, German production of ships for export has been resumed. Generally, it is clear that, over the whole period, German exports have increased faster than those of the other two countries.

CHAIRMAN OF THE BRITISH TRANSPORT COMMISSION.

General Sir Brian Robertson, when he succeeds Lord Hurcomb as chairman of the British Transport Commission at the end of this month, will have a wider responsibility than any other man in the industrial life of this country, if the number of employees can be regarded as a fair index. As the head of an organisation employing a staff of 900,000, he will control the services of about 4 per cent. of the working population, and his indirect influence on the efficiency and prosperity of the nation will be correspondingly extensive. As a soldier he will be quick, no doubt, to appreciate the traditions and innate loyalties of railwaymen; as a former Sapper officer he will share the long-standing bond between the Royal Engineers and the railways; and as one-time managing director of Dunlop South Africa, Limited, he will be able to bring commercial experience to the essentially commercial problems of British transport. The Commission are embarking on a period of re-adjustment after nearly six years of nationalisation. Under the terms of the Transport Act, 1953, they are required to dispose of their road-haulage undertaking and decentralise railway management, and to some extent they will be making a fresh start. The post of chairman during this period, therefore, calls for exceptional qualities of leadership and administrative skill. During the immediate post-war years the railways worked under difficult conditions, which, in many respects, they were powerless to alter. The outlook is now, perhaps, brighter, and railwaymen and the public alike will hope that Sir Brian Robertson's pattern of success during the war—when, as a senior officer, he grappled with administrative problems during the disheartening months of 1941 and 1942 in the Western Desert, and then during the triumphs of 1943 and 1944—will be repeated in his new post in transport. He will be building on the foundations laid by his predecessor. Lord Hurcomb, who is 70 years of age, tackled one of the heaviest of the new industrial responsibilities created by post-war politics when he become the first chairman six years ago. Although his successor has a major task of reorganisation ahead, the conditions are fortunately not so severe. The announcement from 10, Downing-street states that the Secretary of State for War has agreed to release General Robertson from the post of Adjutant General to which he was recently appointed, and that he will take up duty as soon as the negotiations with Egypt have reached a sufficiently advanced stage.

CONDITIONAL AID FUND FOR INDUSTRY.

Notes exchanged in February between the Foreign Secretary and the United States Ambassador established a programme for the expenditure of the counterpart funds from American economic aid under the Mutual Security Act of 1952 (Cmd. 8776). As part of this programme a "revolving" fund of 1*l*. million has been set up for short-term loans to industry and agriculture. Agriculture receives 300,000*l*., and the balance of 700,000*l*. is available for short-term loans to industry for increasing productive efficiency. The President of the Board of Trade has appointed an independent Committee to advise him on the administration of the industrial portion of the Revolving Fund. The President has accepted the Committee's recommendations on the types of project which should be aided from the Fund, and the terms and conditions to be attached to the loans within the framework laid down in the White Paper. The Advisory Committee are now ready to examine individual applications from industry and will make recommendations thereon to the Board of Trade. Any project for raising productive efficiency in industry is eligible for consideration. Since the amount of money available is limited, it will be necessary to restrict loans to projects which will contribute quickly to achieving the purposes of the Fund, and it is expected that most of the loans will be made for new equipment and improvement of plant layout. Preference will be given to small and medium-sized firms who can show that the benefits they expect to accrue from a loan will enable them (or their customers) to expand their export trade or to meet essential home requirements more efficiently. Loans will not normally be granted for periods of more than three years, though in exceptional circumstances up to five years may be considered. Applications are unlikely to be entertained for large sums. No fixed minimum or maximum has been laid down, but first consideration will be given to loans which do not exceed 30,000*l*. The amount and period of the loan and the rate of interest and the security required will be matters for negotiation, but it is intended that the terms for approved projects shall not be less favourable than those which the applicant can obtain from other sources. An explanatory leaflet setting out the form in which applications should be made can be obtained from the Board of Trade, Industries and Manufactures Division 2 (Revolving Fund for Industry), Horse-guards-avenue, London, S.W.1, or from Board of Trade Regional Offices.

THE ABERNANT COLLIERY PROJECT, SOUTH WALES.

In order to exploit the considerable resources in the anthracite district of the South Wales coalfield, work is to begin shortly on the sinking of pits ten miles north-east of Swansea at a point midway between Gwaun-cae-Gurwen in the Amman Valley and Pontardawe in the Swansea Valley. A virgin area of anthracite, roughly five miles from north to south and five miles from east to west, and lying at a depth of about 800 yards, is to be worked. Under a 6,000,000*l*. scheme approved by the National Coal Board, a modern colliery will be laid out to provide an annual saleable output of 750,000 tons of first-grade anthracite. The workable reserves available from the workings at the colliery are assessed at 134 million tons. Employment will be provided for 2,000 men and it is expected that the output per manshift will be at least 30 cwt. The project is the largest of several developments planned in the No. 9 (Neath) Area of the South-Western Division of the National Coal Board. There are 32 pits in this administrative area and, of these, 28 produce anthracite. The new mine is to be known as Abernant Colliery and the first sod, it is expected, will be cut in the near future. The work of sinking the shafts put in hand soon afterwards, will take from two to three years to complete. The shafts will be the deepest in the anthracite coalfield. The new colliery is to lie in a broad valley with two miles of open country—mostly scrub land—on each side of it. A main road passes the site and on this runs a frequent omnibus service along the route from Neath to Ammanford. Consequently, the location has the dual advantage that subsidence is unlikely to affect housing and that there will be ready access to the colliery from Pontardawe and other places in the Swansea Valley, and from Cwmgorse, Gwaun-cae-Gurwen, Garnant, Glanamman, Ammanford, and other localities in the vicinity.

THOMAS NEWCOMEN (1663-1729).

On Sunday last, August 16, the 224th anniversary of the death of Thomas Newcomen, who made the first piston steam engine, was marked at Dartmouth, his birthplace and home, by the laying of commemorative chaplets on the memorial which stands in the Royal-avenue Gardens. The ceremony, which is now an annual event, was attended by the Mayor of Dartmouth (Mr. H. J. Adams) and a number of members of the Council. Four wreaths were deposited, by Mr. J. Foster Petree, M.I.Mech.E., as President of the Newcomen Society for the Study of the History of Engineering and Technology; by Mr. B. Magenis, on behalf of the Newcomen Society in North America; by Mr. F. C. B. Kirk, of Messrs. Philip and Son, Limited, the Dartmouth shipbuilders, who is chairman of the Dartmouth Newcomen Association; and by Mr. Eric Downing, on behalf of the Dartmouth Baptist Church, of which Newcomen (who carried on the business of an ironmonger in the town) was pastor for 20 years. On the previous day, under the auspices of the Dartmouth Newcomen Association, a luncheon was held as part of the commemoration; after which, under the guidance of Mr. Percy Russell, F.S.A., honorary curator of the Dartmouth Museum, the party inspected the progress of the repairs now in hand to the Seventeenth-Century buildings in the Butterwalk, severely damaged by bombing during the war, where it is intended, eventually, to establish a Newcomen museum in a room to which have been transferred some 70 linenfold panels formerly in Newcomen's own house, demolished in 1864.

LETTER TO THE EDITOR.

PROBLEMS OF FLUID-FLOW MEASURING DEVICES.

TO THE EDITOR OF ENGINEERING.

SIR,—In the article by Mr. F. V. A. Engel on the above subject, published in your issues of July 3 and 10, on pages 6 and 35, a review is made of factors influencing the discharge coefficient of orifices, nozzles and Venturis. One subject of study is illustrated by Fig. 1, on page 6, *ante*, where, in many cases, the discharge coefficient falls quickly with increasing Reynolds number. The object of this note is to point out that a similar dependence of discharge coefficient upon velocity can arise in circumstances in which Reynolds number is not the appropriate dimensionless number.

This arises in liquid flow when the cavitation number defined below falls below a value which is characteristic of the geometry. The cavitation number is

$$K = \frac{p - p_v}{\frac{\rho v^2}{2g}},$$

where ρ = density of liquid, p_v = vapour pressure of liquid, p = pressure at a reference point, and v = velocity at a reference point. It is often convenient to use this in the form

$$K = \frac{p_1 - p_v}{p_1 - p_2},$$

where p_1 = upstream pressure and p_2 = downstream pressure.

The geometry of Fig. 1 (*a*) D, of the article is a case where cavitation effects may easily occur. These are due to the low pressure at the upstream corner, arising from the high velocity at that point. When the corner is sharp enough the pressure falls below the downstream pressure by an amount which is proportional to the flow. By increasing the flow this depression can be made to reduce the total pressure below the vapour pressure of the liquid. A cavity is formed and the flow separates from the wall.

Our experience of this effect is confined to the case similar to Fig. 1 (*a*) D, but in which the orifice discharges directly to atmosphere. A result obtained in this laboratory some years ago has been found to correlate with N.A.C.A. results* on the basis of cavitation number. Indeed the latter results are better correlated among themselves on this basis, as shown in the accompanying graph, than on the Reynolds number. Although this effect and its explanation have been known in this laboratory for some years, it has only very recently become the subject of detailed investigation.

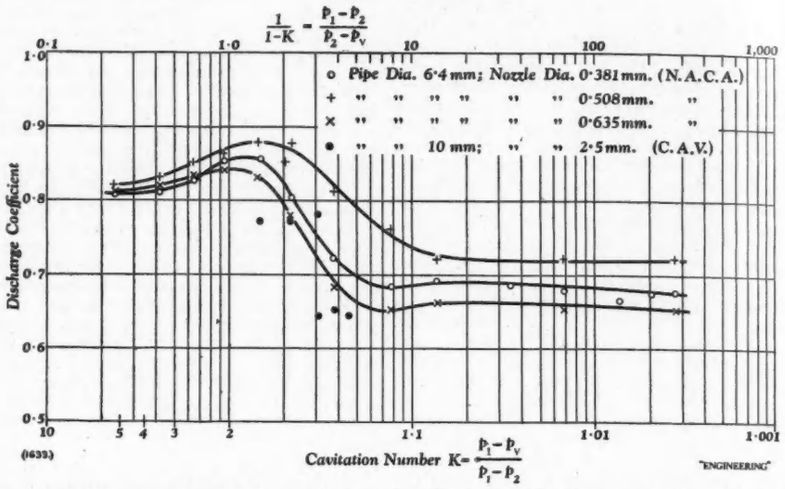
Yours faithfully,
B. E. KNIGHT.
W. BERGWERK.

C.A.V., Ltd.,
Acton, London, W.3.
August 6, 1953.

* Gelalles, A. G., N.A.C.A. Report No. 373, 1931.

FLUID-FLOW MEASURING DEVICES.

SHARP-EDGED NOZZLES.



OBITUARY.

SIR BERNARD DARLEY, C.I.E.

WE regret to record the death of Sir Bernard D'Olier Darley, which occurred on August 11, within a few days of his 74th birthday.

Bernard D'Olier Darley was born in Ireland on August 24, 1880, and was educated at the High School and Trinity College, Dublin. At the age of 20 he joined the Royal Engineering College, Coopers Hill, and after a successful three years' course was appointed assistant engineer in the Irrigation Branch of the Indian Public Works Department, being assigned to duties in the United Provinces. From 1904 to 1906, he was in charge of the construction of the headworks of the Ganges Canal, and during the following two years he was responsible for famine works, besides surveying and preparing projects for the Mizapur and Benares State canals and for the water works of the city of Mirapur. After serving a short time as executive engineer in the Ken canal division he was placed in charge of the construction of the two canals just mentioned, a position he held until 1917 when he became executive engineer and superintendent of the Tarai and Bhabar estates. A year later he prepared a project for the construction of the Sarda-Oudh canal and was subsequently engaged in its construction, first as superintending and then as chief engineer. After completing this scheme in 1930 he continued for a time as chief engineer and also acted as secretary to the Government of the United Provinces for the Irrigation Branch of the Public Works Department. In 1932, he was appointed chief engineer of Bahawalpur State, Punjab, a position he held until his retirement in 1937. For a short time after his return to this country he was technical adviser to the Air Raids Precautions Department of the Home Office. Sir Bernard, who was knighted in 1928 and had been a Companion of the Order on the Indian Empire since 1919, was elected an associate member of the Institution of Civil Engineers in 1906 and transferred to the class of member in 1932. In 1932, he received a Telford Medal for a paper on "The Design and Construction of the Sarda Canal." He was also the recipient of an Indian Premium.

DR. G. L. KELLEY.

WE regret to record the death, on July 25, of Dr. George Leslie Kelley, deputy chairman and former managing director of the Pressed Steel Company, Limited. Dr. Kelley, who was born in 1879 at Quincy, Massachussetts, was a graduate of Harvard University, where he took a B.Sc. degree in 1907 and was awarded a Ph.D. in chemistry four years later. He continued at Harvard as an Austin Teaching Fellow until 1909, and was then appointed instructor in chemistry, and later an associate professor. During this period he became associated with the Midvale Steel Company, of Philadelphia, and eventually joined their staff as chief metallurgist, remaining with them until 1921. He then went to the Edward G. Budd Company, also of Philadelphia, as research director. In 1931, he came to England to take up the appointment of general manager of the Pressed Steel Company. In the United States, he had been responsible for many developments in the working of sheet steel, especially in its application to motor-car construction; for example, the levelling of sheet steel for deep drawing, and the taper rolling of steel for disc wheels. In this country, he sponsored the development of the "unitary" body—that is, motor-car body construction without chassis members. In 1940, Dr. Kelley was appointed a director, and in 1942 succeeded the late Mr. Otto Mueller as managing director, a position which he held until 1946, when ill-health obliged him to relinquish it. He remained on the board, however, and was deputy chairman from 1947 until his death.

During the second World War, Dr. Kelley was actively and responsibly engaged in the production of a wide variety of sheet-metal components, in which he found full scope for his scientific knowledge and ingenuity. He edited and partly wrote a book describing the construction of metal air-frame parts, and contributed much to the successful development of the cold extrusion of steel for shells, aircraft bombs, and cartridge cases, and the cold drawing of steel hemispheres for mines, for the Admiralty. After the war, he turned his attention to the production of all-steel prefabricated houses. In earlier years, he did much original work on the production of urea formaldehyde plastics.

Dr. Kelley was a member of the Society of Automotive Engineers, in the United States, and of the former Institution of Automobile Engineers in this country. For his contributions to science and industry, the University of Oxford conferred upon him the honorary degree of Master of Arts. He was also a governor of the Oxford technical school, a director of the Anglo-American Chamber of Commerce, and a vice-president of the Sheet and Strip Metal Users' Technical Association.

MEASUREMENT OF WAVE HEIGHTS IN MODEL HARBOUR.

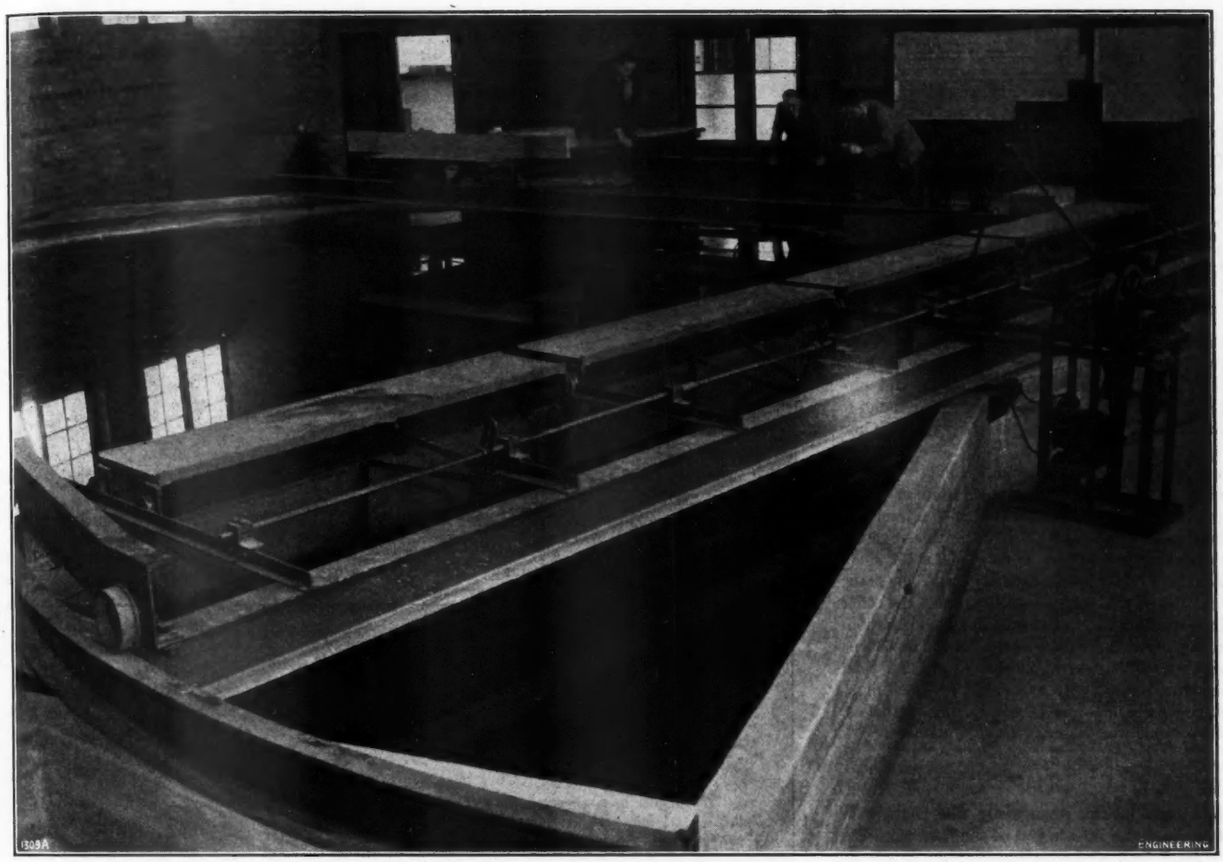


FIG. 1. MODEL OF CAPE TOWN HARBOUR.

THE MEASUREMENT OF WAVE HEIGHTS IN THE MODEL OF TABLE BAY HARBOUR.

By B. W. WILSON, D.Sc., A.M.I.C.E.*

IN 1942-43, the design of a model of Table Bay and its harbour was undertaken at Cape Town, under the auspices of the South African Railways and Harbours Administration, for the study of the wave and surge phenomenon, commonly known as "range,"† which had proved troublesome to war-time shipping. The model, which is illustrated in Fig. 1, herewith, occupies almost the whole area of a room measuring about 40 ft. by 50 ft. It is enclosed in a tank about 20 in. deep in which the bay has been reproduced to a horizontal scale of 1:1,200 and a vertical scale of 1:144, with the sea bed correctly moulded in mortar except in the vicinity of the harbour, where it is moulded in sand to permit conveniently of bedding down the experimental breakwaters and piers. A portion of the model harbour is illustrated in Fig. 3, on page 246, which shows the Victoria, Alfred and Duncan Basins. Fig. 1 is a view taken from the Robben Island end of the western channel paddle, looking across the model bay towards the harbour. A travelling platform covers the harbour area; a member of the staff is seen kneeling upon it. A second paddle and its driving mechanism, not shown in Fig. 1, is located to the left. The paddles, with their frames and the driving mechanisms, can be swivelled on circular tracks about pin joints located at the re-entrant angles of the tank walls.

When, at that time, it became necessary to consider ways of recording effects within the model, the World War was at a very critical stage, and materials and instruments, in particular, were difficult to secure. The prospect of acquiring any suitable instruments from overseas appeared hopeless and no suitable instruments were procurable in South Africa, so that it became necessary to improvise with available local materials. As all electrical apparatus was very scarce, it did not appear feasible to elaborate an electrical instrument, using oscillographs and other complex units.

Fortunately, the quest for a suitable instrument for the prototype harbour, leading to the design of the "seichometers,"* suggested a principle that might be worthy of development on a model scale. It had been used successfully for remote-control deep-sea tide-gauges and depended on the transmission of pressure through an air-column in a pipe connecting an air-cylinder, immersed in the sea, with a recording fluid-manometer,† as shown in Fig. 2 on page 246. Adapting the principle to an instrument suitable for precise measurements of small water-movements in a model involved many problems and considerable experimentation.

By way of explanation of the "range" which it was the purpose of the model to reproduce, and of the term "seichometer," mentioned above, a quotation may be made from the present author's paper, published by the American Society of Civil Engineers in 1950.* In that paper, it was stated that "Range action or surge action connotes essentially a motion of water induced by seiches, operating within the confines of a harbour basin. The term 'seiche' itself implies a resonant oscillation of water or 'standing wave,' sustained by disturbing forces, such as marine or atmospheric wave trains, whose impressed frequency coincides or closely concurs with the natural frequency of oscillation of the body of water within the boundaries of the basin. The rhythmic variations of water level at the extremity of Lake Geneva, in Switzerland, were described as seiches more than 200 years ago.

"It usually happens that seiches occur in complex combinations involving both fundamental and higher harmonic modes of oscillation along the principal axes of the basin. The higher frequencies of oscillation are undoubtedly stimulated, for the most part, by visible storm swells entering the basin, whereas the invisible ground swells of the incoming train of sea waves generally promote the fundamental seiches. . . . The effect of severe range action on shipping berthed alongside solid quays or jetties is always impressive and sometimes alarming. For no apparent reason, a ship will describe simultaneous translatory motions in

* Associate oceanographer, Dept. of Oceanography, Texas Agricultural and Mechanical College, College Station, Texas, U.S.A.

† Cf. "The Sturrock Graving Dock, Cape Town," by D. E. Paterson, *Proc. S.A. Soc. C.E.*, vol. 45, pages 64-67 and 180-183 (1947).

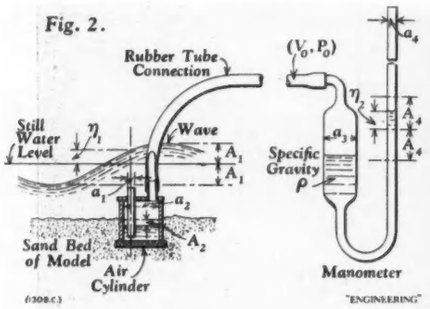
* "Measurement of the Range Phenomenon in Table Bay Harbour," by B. W. Wilson. *S.A. Railways and Harbours Mag.*, June, 1952.

† Cf. Field and Cust's tide-recorder as developed by the Cambridge Scientific Instrument Co., *Dictionary of Applied Physics*, 1923, vol. III, page 546; and Honda, "A Portable Aero-Mercurial Tide-Gauge," by K. Honda *Phil. Mag.*, vol. X, pages 253-259 (1905).

* "Ship Response to Range Action in Harbor Basins." *Proc. A.S.C.E.*, Separate No. 41 (1950); or *Trans. A.S.C.E.*, vol. 116, pages 1129-1157 (1951).

MEASUREMENT OF WAVE HEIGHTS IN MODEL HARBOUR.

Fig. 2.



three dimensions within the compass of her mooring ropes. There have been cases, especially with large ships, where this action has been severe and prolonged enough to break all the mooring ropes and to splinter the timber fendering between the ship and the quay."

For his portable tide-gauge, Honda* used a mercury manometer, in the small limb of which a conveniently small movement of the mercury column could represent a fairly large tidal fluctuation over the air cylinder. On a model scale, small variations of water-level obviously could not make any sensible impression on mercury, and some other manometric fluid had to be sought. It was questionable, also, whether Honda's theory for the prototype instrument, which was applicable to gradual tidal movements, would apply to a model in which high-frequency recording was necessary. Nevertheless, Honda's result was taken as a guide, namely,

$$\frac{\eta_1}{\eta_4} = \frac{a_4}{a_2} + \rho\left(1 + \frac{a_4}{a_2}\right), \text{ approximately,} \quad (1)$$

where η_1 and η_4 are, respectively, the changes in level of the water surface and of the fluid meniscus in the small limb of the manometer; a_2, a_3 and a_4, respectively, the cross-sectional areas of the air-cylinder, large limb and small limb of the mano meter; and ρ the density of fluid in the manometer (Fig. 2.) Transposing, (1) may be expressed as

$$\rho = \frac{\left(\frac{\eta_1}{\eta_4} - \frac{a_4}{a_2}\right)}{\left(1 + \frac{a_4}{a_2}\right)} \quad . \quad . \quad . \quad (2)$$

By aiming at making the meniscus movement, η_4, the same as the wave movement to be measured in the model, for which $\frac{\eta_1}{\eta_4} = 1$ in equation (2), it was clear that the density of the manometric fluid had to be less than unity. Numerous experiments with various light oils and volatile fluids were therefore made on an improvised manometer and air-cylinder, and eventually it was found that pure paraffin, with a specific gravity of about 0·88, gave an encouraging performance.

A theoretical investigation of the relationships that would prevail when the water-level over the air-cylinder performed a sinusoidal rise and fall $\eta_1 = A_1 \sin p\,t$ with an angular frequency $p = \frac{2\pi}{\tau}$, or periodicity τ, was next undertaken and led to the results :—†

$$\text{(i)}\ p = \frac{a_1}{a_2}\frac{R}{A_2}\left(2g\right)^{\frac{1}{2}}\left[A_1^2 - \left\{A_2 + \rho A_4\left(1 + \frac{a_4}{a^2}\right)\right\}^2\right]^{\frac{1}{2}}$$

$$\text{(ii)}\ \frac{A_2}{A_4} = \frac{a_4}{a_2}\left\{1 + \frac{V_0\,\rho\,g}{a_4\,P_0}\left(1 + \frac{a_4}{a_2}\right)\right\},$$

* *Loc. cit.*

† As the full derivation of these formulæ is complicated and of exceptional length, it has been omitted.

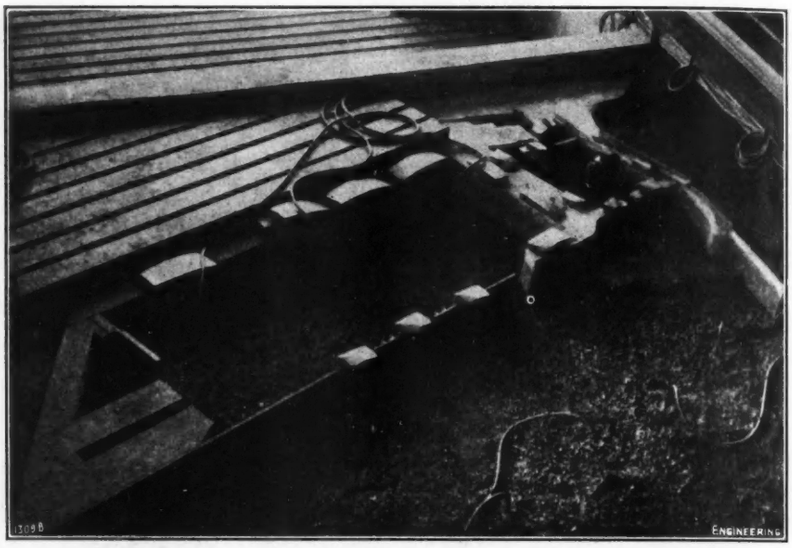


Fig. 3. View of Model, Showing Connecting Tubes to Manometers.

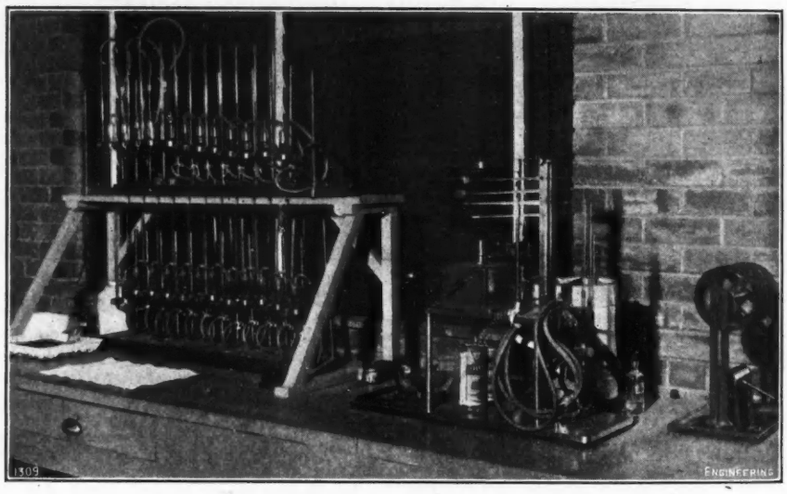


Fig. 4. Wave Manometers and Recording Kymatograph.

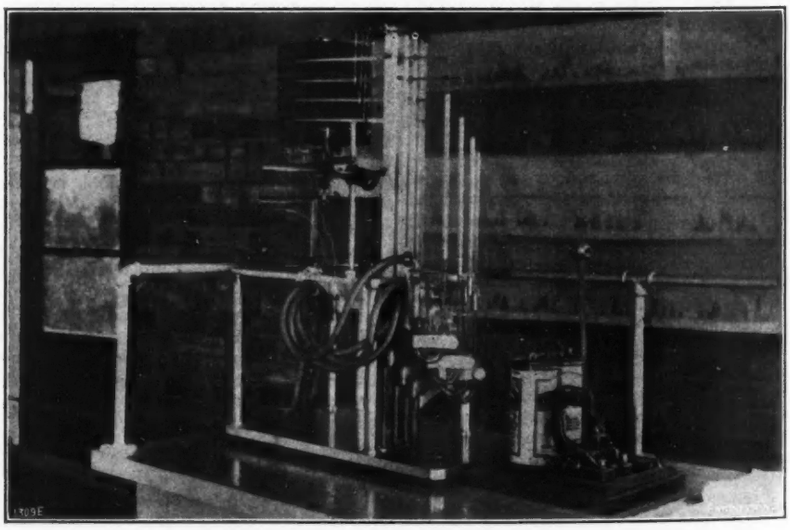
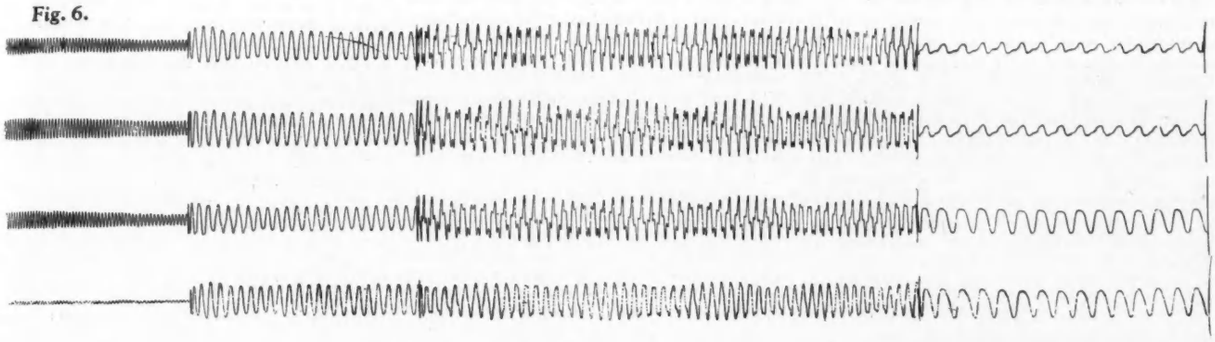


Fig. 5. The Kymatograph, Recording Water-Surface Elevations at Four Points Simultaneously.

MEASUREMENT OF WAVE HEIGHTS IN MODEL HARBOUR.

Fig. 6.



(iii) $$R = \int_0^{\frac{\pi}{2}} \sqrt{\cos\theta}\,.\,d\theta = 0{\cdot}3814.\pi \ *$$ (3)

Here a_1, a_2, a_3 and a_4 are, respectively, the cross-sectional areas of the vent-tube of the air-cylinder, the air-cylinder itself, the large limb and the small limb of the manometer; A_1, A_2, A_4, the amplitudes of vertical displacements, respectively, of the water surface being measured, the water surface in the air-cylinder, and the fluid meniscus in the small limb of the manometer; V_0 and P_0, respectively, the initial volume of air and the initial pressure of air in the air-cylinder and connecting tube to the manometer, under static conditions.

As the sizes of glass tubing available for the manufacture of manometers were distinctly limited, it was found necessary to select large and small bore diameters of 20 and 6 mm., respectively. Further, as a result of trial experiments, it was decided to adopt a vent-tube diameter of 3 mm. for the air-cylinder. This left the internal diameter of the air-cylinder to be determined.

By the use of equation (1), for which $\frac{\eta_1}{\eta_4}$ was taken as unity and ρ as 0·88, the diameter of the air-cylinder, to give full-scale reproduction of wave heights, was computed to be about 30 mm. This was the cylinder size actually adopted, but, before accepting it, check calculations were made by the use of equation (3) to verify that the manometer would reproduce the water movement to the full scale at all periodicities above about one second. At the last minute, it was announced that tubing of 20-mm. bore was unprocurable and 25-mm. bore had to be accepted in lieu thereof. It was decided, nevertheless, to retain the 30-mm. size of air-cylinder.

For the air-cylinder and manometer sizes adopted (which, besides the bore dimensions already mentioned, included lengths of 32 and 60 mm., respectively), and for an assumed 30-ft. length of 6-mm. rubber tubing connecting the units, equations (3) resolve to

$$\tau = \frac{5{\cdot}092\,A_4}{\sqrt[4]{A_1^2 - 1{\cdot}019\,A_4^2}} \quad . \quad . \quad (4)$$

If it is considered that all the waves to be measured (of whatever periodicity τ) have an amplitude, A_1, of $\frac{1}{4}$ in. or 0·02 ft., the corresponding amplitude of the movement, A_4, reproduced in the small limb of the manometer by the oscillations of the meniscus of the paraffin, may be calculated from equation (4). Thus, the periodicities that will make A_4 have the successive values given in the first column of Table I, herewith, are:

From a design point of view, the magnifications at the different frequencies indicated in Table I were considered satisfactory. Thus, a magnification of 0·6 or better was ensured for all periodicities of waves in the model above 0·65 seconds, corresponding to about one minute in nature for the model scales adopted (horizontal 1 : 1,200, vertical 1 : 144).* Actually, the magnifications, as realised, were even better than these. On this theoretical and experimental basis, the design for a model recording-system was evolved and put into practice.

* The value of this integral was obtained by graphical means.

DEVELOPMENT OF THE KYMATOGRAPH.

A battery of "wave manometers," as they came to be called, was installed in the range laboratory in two tiers, as shown in Fig. 4, opposite; the wave manometers are to be seen on the left. They were found to be particularly useful and effective in showing up the nature of the oscillations occurring outside the model harbour during operation of the wave-paddles. A whole series of small air-cylinders, embedded fairly close together in the sand bed of the model between the breakwater and the shore, and connected by rubber tubing (see Fig. 3) to the banks of manometers, could give an impression on the latter of an instantaneous profile of the water-surface along the line of the cylinders. It was easy, in this way, to demonstrate the existence of the uninodal and multinodal "seiches" in the breakwater-shore oscillating system.

TABLE I.—*Theoretical Prediction of Performance of Model Recording System.*

Amplitude Manometer $A_4 \times 10^{-3}$ ft.	Periodicity τ secs.	Magnification A_4/A_1.	Amplitude Manometer $A_4 \times 10^{-3}$ ft.	Periodicity τ secs.	Magnification A_4/A_1.
0·2	0·09	0·1	1·2	0·65	0·6
0·4	0·18	0·2	1·4	0·81	0·7
0·6	0·28	0·3	1·6	1·02	0·8
0·8	0·39	0·4	1·8	1·37	0·9
1·0	0·51	0·5	2·0	∞	1·0

This arrangement was not used except for making general qualitative comparisons. To secure autographic records, attempts were made to harness the fluid in the small limb of the wave-manometers for actuating a float and lever system, even though the available momentum for this was so small and the frictional effects so large. Experiments were so encouraging that a four-lever recording instrument, termed a Kymatograph and shown in Figs. 4 and 5, opposite, was developed.

The instrument consisted of an elevated stand for a clockwork-driven drum, on which scribe four lever-pens, the fulcrums of which were carried on the columns of the instrument. Sliding on these columns, below the upper deck, were the manometer-holders, which could be locked on the columns in any positions by means of hand-screws. The glass manometers were rigidly held in the holders so that their small limbs were vertical beneath the ends of the levers. Small aluminium floats rode on the surface of the paraffin and actuated the levers through fine suspender-rods.

* The range-action model at Cape Town was designed for long-period waves in the periodicity band from about 1 to 10 minutes (in nature).

Before the Kymatograph could be turned into a useful and reliable instrument, many practical difficulties had to be overcome. Various lengths of float (made from aluminium detonator tubes) were tried in conjunction with various types of suspender-rods, but the results were disappointing until single loops of wire were soldered round the middle of the floats so that only ring-contact was possible with the glass. It was found necessary, too, that a float should be wholly immersed in the paraffin with its top in the meniscus, so that a film of paraffin could act as a lubricant round it, while the normal surface-tension of the meniscus was harnessed as a propelling force in addition to the float-buoyancy.

It remained a matter of some delicacy to ensure that the centre-lines of the floats were always co-axial with the suspender-rods: any deflection of serious proportions was liable to tilt the float askew in the manometer limb and to impede its free functioning. With careful attention to such matters, which included also occasional cleaning of the insides of the float tubes for the removal of dust, the Kymatograph was found to be a valuable and reasonably trustworthy recording instrument. Fig. 6, herewith, is a "kymatogram" giving four simultaneous recordings of water-surface movements at points in the model selected at random, and illustrates the often beautiful effects recorded with this apparatus.

The Kymatograph could record wave-movements in any part of the model bay by the simple provision of rubber tubing long enough to reach to the farthest corners; in this respect, it was particularly useful and versatile. It was necessary, of course, that all four manometers should be connected with tubing of the same length, since their sensitivity (equation (3) (ii)), is a function of the volume, V_0, of the air-column. When long-distance measurements had been completed, it was found expedient to shorten the tubing as much as possible, to improve the sensitivity for the final experiments.

(To be continued.)

R.E.M.E. OFFICERS' DINNER.—The annual dinner of R.E.M.E. officers is to be held on Friday, October 23, at the Holborn Restaurant, High Holborn, London, W.C.1, at 7 p.m. Tickets are obtainable at 22*s.* 6*d.* each (cheques made payable to "R.E.M.E. Dinner Fund") from the secretary, R.E.M.E. Dinner Committee, Room C505, War Office, Chessington, Surrey.

SURVEY OF AUSTRALIAN ENGINEERING RESEARCH.—The Institution of Engineers, Australia, have issued a directory of engineering research activities entitled "A Survey of Australian Research." The directory is divided into nine groups representing the Commonwealth and six state government departments, universities and technical colleges, and private organisations. Within each group, the individual organisations are listed alphabetically, and particulars are given of their research staff; the fields covered; research activities completed, current, and contemplated; equipment and facilities; advisory services; and publications. A comprehensive subject index is included.

WROUGHT NICKEL-MOLYBDENUM ALLOYS.

THE addition of molybdenum to nickel, or to nickel containing small percentages of iron, produces alloys which are strongly resistant to corrosion by hydrochloric and phosphoric acids and, to a lesser extent, by sulphuric acid. The initial work on these alloys was carried out in the United States and Germany, but, for some years past, the alloys have been produced in this country in the form of castings. Wrought forms of the alloys, however, are also required, often for use in conjunction with castings, and engineers concerned with corrosion problems will be interested to learn that Henry Wiggin and Company, Limited, Wiggin-street, Birmingham, 16, have commenced the manufacture of wrought nickel-molybdenum alloys, to which they have given the name of "Corronel B." Previous work on nickel-molybdenum alloys, supplemented by investigations conducted at Birmingham, show that corrosion resistance improves with increased molybdenum content and that additions of up to 10 per cent. of iron at the 30 per cent. molybdenum level have no significant influence on corrosion rates. The composition of Corronel B is approximately 66 per cent. of nickel, 28 per cent. of molybdenum, and 6 per cent. of iron. The new alloy, it is stated, can be satisfactorily worked, although it offers greater resistance to deformation than mild or low-alloy steels. It is claimed to be highly resistant to hydrochloric acid at all concentrations and temperatures, and to possess excellent resistance to sulphuric and phosphoric acids in certain ranges of concentration.

LAUNCHES AND TRIAL TRIPS.

M.S. "BOLIVAR."—Single-screw cargo vessel, built by the Helsingborgs Varfs A/B, Helsingborg, Sweden, for the Rederi A/B Våring, Stockholm. Main dimensions: 285 ft. 6 in. by 41 ft. by 24 ft. 3 in.; deadweight capacity, 2,520 tons. Burmeister & Wain five-cylinder oil engine, developing 1,625 i.h.p. Service speed, 13½ knots. Trial trip, July 16.

M.S. "NICOLAS."—Single-screw oil tanker, built by the Blythswood Shipbuilding Co., Ltd., Scotstoun, Glasgow, for the Parana Compañia de Vapores, S.A., Panama City (Managers: Lyras Brothers, Ltd., London, E.C.3). Main dimensions: 530 ft. between perpendiculars by 72 ft. 9 in. by 38 ft. 8 in.; deadweight capacity, about 18,600 tons on a draught of 30 ft. 7 in. Harland-B. and W. six-cylinder two-stroke single-acting opposed-piston Diesel engine, developing 7,500 b.h.p., supplied by John G. Kincaid & Co., Ltd., Greenock. Speed on trial, fully loaded, 15½ knots. Trial trip, July 28.

S.S. "RATHLIN HEAD."—Single-screw cargo vessel, with accommodation for twelve passengers, built and engined by Harland and Wolff, Ltd., Belfast, for the Ulster Steamship Co., Ltd. (Managers: G. Heyn and Sons, Ltd.), Belfast. Main dimensions: 405 ft. between perpendiculars by 58 ft. 9 in. by 39 ft. to shelter deck; gross tonnage, about 7,350. Double-reduction geared steam turbines, developing 5,000 s.h.p. in service, and two Babcock and Wilcox boilers. Launch, August 10.

M.S. "BORDER KEEP."—Single-screw oil tanker, built by the Blythswood Shipbuilding Co., Ltd., Scotstoun, Glasgow, for the Lowland Tanker Co., Ltd. (Managers: Common Brothers, Ltd.), Newcastle-upon-Tyne. Main dimensions: 515 ft. between perpendiculars by 69 ft. 6 in. by 37 ft. 6 in.; deadweight capacity, about 16,000 tons. Rowan-Doxford six-cylinder opposed-piston two-stroke oil engine, developing 6,800 b.h.p., constructed by David Rowan & Co., Ltd., Glasgow. Launch, August 12.

S.S. "PATONGA."—Single-screw cargo vessel, built and engined by Alexander Stephen and Sons, Ltd., Linthouse, Glasgow, for the Peninsular and Oriental Steam Navigation Co., Ltd., London, E.C.3. Main dimensions: 469 ft. 6 in. by 64 ft. 6 in. by 42 ft.; deadweight capacity, 9,950 tons on a draught of 27 ft. 4 in.; gross tonnage, 10,110. Double-reduction geared steam turbines, developing 9,000 s.h.p. at 104 r.p.m., and Foster Wheeler oil-burning boilers. Service speed, 16 knots. Launch, August 11.

M.S. "BRANSDALE H."—Single-screw tank barge, built by Cook, Welton and Gemmell, Ltd., Beverley, Yorkshire, for John Harker, Ltd., Knottingley, Yorkshire, for service on canals and inland waterways between the Humber and West Yorkshire. Third vessel of a series for these owners. Main dimensions: 138 ft. between perpendiculars by 17 ft. 6 in. by 6 ft. 6 in. Diesel engine, working through reduction gearing, and developing 160 b.h.p. at 900 r.p.m., constructed by Gleniffer Engines, Ltd., Glasgow. Launch, August 12.

LABOUR NOTES.

FROM a labour point of view, probably the most important event in Britain during the past fortnight has been the four-day annual conference of the Confederation of Shipbuilding and Engineering Unions at Great Yarmouth, which opened on August 11. This body is an affiliation of 38 unions catering wholly or mainly for employees in the engineering, shipbuilding and associated industries, and much of the opening address of the Confederation's President, Mr. H. G. Brotherton, was devoted to explaining the demands of the Confederation for an increase of 15 per cent. in the wages of the three million operatives employed in this group of industries. These demands are at present under consideration by the respective employers' organisations, the Engineering and Allied Employers' National Federation and the Shipbuilding Employers' Federation.

Since the summer of 1947, Mr. Brotherton stated, there had been an advance of more than 40 per cent. in the cost of living, while the average earnings of workpeople in the engineering and shipbuilding industries had risen by only 34 per cent. This comparison did not, however, include payments in respect of overtime. The unions did not think it right to include such extra money, as they considered that all such payments were very adequately earned, on account of the strain and loss of leisure which work outside a man's regular hours involved. During the same period, productivity had increased by about 50 per cent. and profits had been doubled. Mr. Brotherton contended that, having regard to these percentages, a substantial increase in engineering and shipbuilding wages could be granted out of profits, without the need for raising the prices of the industries' products.

Mr. Brotherton's restatement of the case in favour of the increase of 15 per cent. in wages was made primarily, he said, for the benefit of that section of public opinion which was genuinely concerned about the merits of the men's demands. He put forward the view that the restrictions which had been imposed on this country's exports were a much more serious obstacle to prosperous trading conditions than advances in wages would be. Mr. Brotherton's suggestions that public support should be sought for the wage increase brought reports from a number of local secretaries that their districts had already started propaganda campaigns among the rank and file of their unions.

Some sharp exchanges took place on the following day, when a resolution was moved, on behalf of the executive council, proposing that a publicity campaign be inaugurated in support of the wage claim. It also drew attention to the decline in the earnings of engineering and shipbuilding employees, the rise in profits in their industries, and the necessity for obtaining the full increase demanded. In the ensuing discussion, Mr. J. Tanner, the President of the Amalgamated Engineering Union, condemned the Chancellor of the Exchequer for asking for restraint in the presentation of wage claims, when workpeople had received such a small share of the proceeds of recent increases in productivity. He shed light on the Confederation's earnest desire to gain public sympathy for their wage demand, by stating that the claim might easily be taken into the political field. In the event of an autumn election, there might be arguments concerning the effect of wage increases in the engineering and shipbuilding industries or, at any rate, suggestions that the Confederation's efforts were harming the country. It was essential, therefore, to convince working people that the claim was justified.

Mr. Brotherton said that correspondence reaching the offices of affiliated unions showed clearly that there was no need to try to convince engineering and shipbuilding employees that the claim was justified. The force of the publicity campaign should be directed on operatives in other industries and on the public. Mr. E. J. Hill, the general secretary of the United Society of Boilermakers, spoke of the necessity of securing bigger pay packets if there were to be any further increases in production. At a later stage, he repeated his well-known view that it was immoral nonsense to speak of higher production when the living standards of the working classes were declining. The delegate representing the Electrical Trades Union, Mr. F. Foulkes, affirmed that the engineering employers were some of the most influential in the country and that wage earners in other industries should appreciate that the negotiations now taking place in the engineering and shipbuilding industries would set the pace with respect to wage claims in their own industries.

The dislike of the lower-paid employees for percentage increases was referred to by Mr. J. Matthews, of the National Union of General and Municipal Workers, who followed up his comments in this connection with an attack on what he referred to as the "antics" of the present Government. Mr. J. Stanley, of the Constructional Engineering Union, courted unpopularity with the larger unions by suggesting that the bodies affiliated to the Confederation should use some of their funds to aid the shop stewards, whose organisation causes much anxiety to many unions. He also inferred that his union would be prepared to go to extremes if the current wage claim was not conceded. Mr. J. Leask, representing the Transport and General Workers' Union, warned the delegates that those who sought to use the Confederation's publicity campaign for spreading extreme views might be responsible for destroying unity among the workpeople. The unanimous approval of the executive's resolution brought a remark from the President that this decision surprised no one.

The third day of the conference was mainly occupied with a debate on nationalisation plans for the future. It was soon obvious that the delegates were dissatisfied with the proposals of the Labour Party, as outlined in *Challenge to Britain*, on the ground that these did not go far enough. This attitude, in fact, had been generally expected. It may be recalled that the Labour Party advocate, in that pamphlet, no more than that a number of key machine-tool manufacturing firms should be acquired, that power should be taken by the Government to nationalise any aircraft-manufacturing firm "which falls down on its job," and that some concerns manufacturing mining equipment should be taken over by the State.

The Confederation's motion, on the other hand, gave renewed support to the proposals which had been accepted by the delegates at the annual conference in 1951. These demanded the progressive nationalisation of the whole engineering industry. This year's motion also referred to the "very strong case" which exists for the nationalisation of the aircraft industry, the machine-tool industry, the coal-mining machinery industry, and of firms making railway wagons. It concluded by calling for the inclusion of independent foundries within the iron and steel industry. The motion was proposed by a delegate from the Association of Engineering and Shipbuilding Draughtsmen, who considered that the case for the nationalisation of engineering concerns was strengthened by the amount of money which was being provided by the Government for research purposes. The motion was later carried unanimously.

Demands that the working week in the engineering industry should be reduced from 44 to 40 hours were put forward by a delegate from the Amalgamated Engineering Union and approved unanimously. At the final session, on August 14, the 200 delegates approved, by a substantial majority, a motion calling upon the executive council to oppose all restrictions on international trade with Britain. The main purpose of this motion was the restoration of commerce with China and Eastern Europe. A motion, proposed on behalf of the Transport and General Workers' Union, asked that the National Insurance Act, 1946, be amended so as to enable employees rendered idle by a dispute in which they were not directly concerned to claim unemployment benefit. The motion was approved by a large majority.

SIX-SPINDLE AUTOMATIC FOR 1-IN. BARS.

WICKMAN, LTD., COVENTRY.

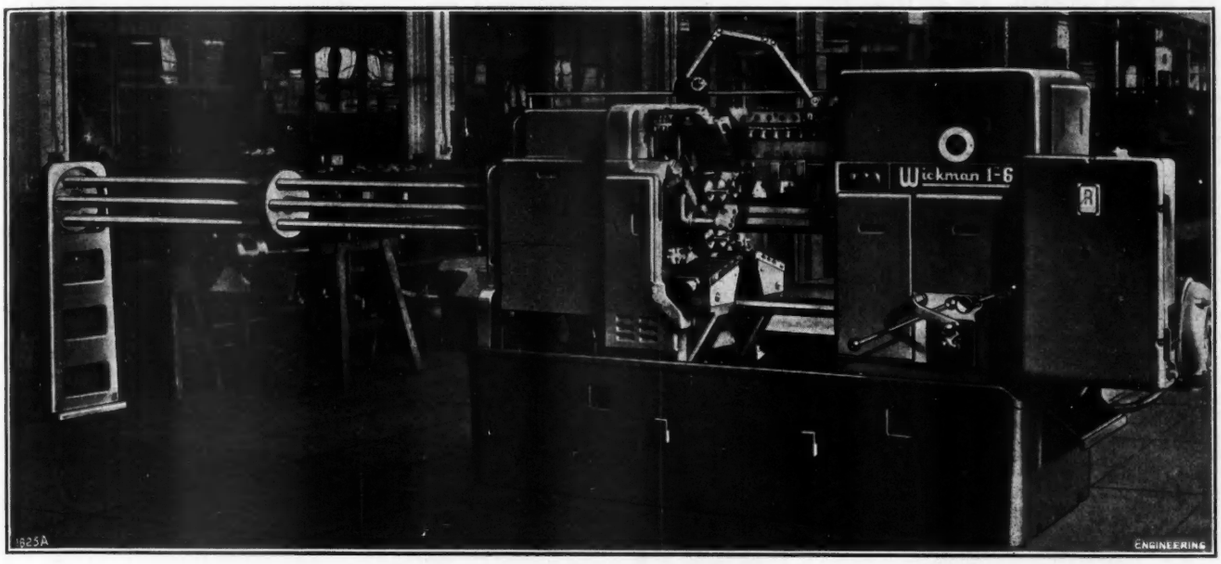


FIG. 1.

Fig. 2.

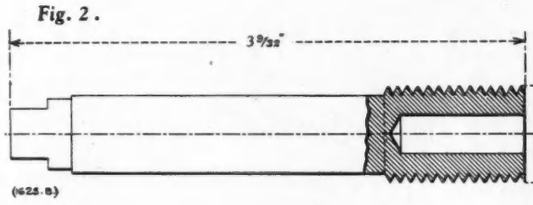
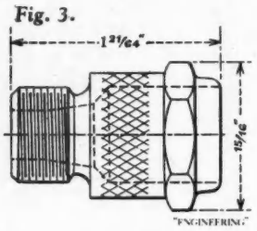


Fig. 3.



SIX-SPINDLE AUTOMATIC FOR 1-IN. BARS.

THE six-spindle automatic of 1-in. capacity shown in Fig. 1 is made by Wickman, Limited, Coventry, and will be shown for the first time at the 3rd European Machine Tool Exhibition in Brussels next month. The machine, which is the smallest in the range of multi-spindle automatics produced by this company, will be demonstrated in two versions: the normal machine with 22 spindle speeds from 247 r.p.m. to 2,510 r.p.m., and a high-speed machine with 24 speeds from 247 r.p.m. to 3,030 r.p.m. The maximum spindle capacity of the machine for round bar is 1 in., for hexagon bar $\frac{15}{16}$ in. across flats, and square bar $\frac{13}{16}$ in. across flats. The length of bar than can be admitted is 12 ft. and the movement of the bar feed is from 0 in. to 5 in. An improved version of the patented Wickman tool-slide stroke-setting mechanism is incorporated and a double bar-feeding mechanism can be fitted to the machine if required. Another feature that is available is a spindle-stopping arrangement to allow side-machining operations. The idle times for indexing and for the approach and return of the tool-slides have been reduced to obtain extremely fast cycle times. The auto-setting mechanisms that have been incorporated enable alterations to the length of the tool-feed strokes to be made in a matter of minutes without changing the cams; this considerably reduces the setting-up time and the change-over time and enables the machine to be used in the production of small batches. The two machines to be shown will demonstrate the production of the sparking-plug bodies and water-tap spindles with generated flats, shown in Figs. 2 and 3; these are produced at the rate of one every 5·4 seconds and 3·2 seconds, respectively.

The base of the machine comprises a heavily-ribbed deep chip-pan, which supports the two main castings housing the drive and the drum assemblies, across which an upper beam is bolted. This assembly of heavy castings forms a closed frame of exceptional stiffness to absorb the high stresses that may be encountered during heavy machining operations. The controlling mechanism for the movement of the centre tool-block and the two auxiliary slides is arranged above the drive-housing and a transversely-mounted camshaft carries the fixed cams and the lever-linkage mechanism, the levers receiving their motion from the standard cams. The tool-feed strokes are adjusted by moving the setting-blocks along the graduated scales fitted to the levers, and the fast approach and draw-back of the tools are controlled by other cams on the same shaft. Similar mechanisms control the movement of the cross-slides by levers which are actuated by the standard cams on the main camshaft running longitudinally through the machine. Alteration to the feed-stroke of the cross-slides is effected by adjusting the position of the levers along graduated scales fitted to rockers which are located behind hinged doors adjacent to the lower cross slides; this does not, however, affect the fast approach and return stroke of the slides. A diminishing rate of feed is provided for the cross-slides to reduce the high tool-pressure that occurs in heavy forming operations.

The main camshaft runs longitudinally through the machine and is driven from the feed-clutch shaft through mitre-wheels and a worm and wheel. In the main-drive housing two cam-drums are provided for the accommodation of cams for standard and special end-working attachments. Additional cams may also be fitted on the camshaft in front of the drive housing. The fixed standard cams for the movement of the cross-slide, the bar-stop, the bar-feed, and drum-locking and collet-operating are fitted on the part of the camshaft which extends into the drum housing. Accommodation is also provided here for fitting additional cams. The upper camshaft, which controls the centre tool block and the two independent longitudinal slides, is mounted transversely across the top of the main-drive housing. The tool-feed strokes of all the slides can be varied without changing the cams by adjusting the sliding-blocks on the adjoining lever system. This gives infinite variation without altering the fast approach and return strokes. Accommodation is also provided on the upper camshaft for additional cams. All the controls, including the safety stop buttons, are duplicated at the rear of the machine, and it cannot be started while either of the stop buttons is in the locked position. A trip is also fitted to disengage the feed which slides back for gauging and tool adjustment. Both the spindle-drum and centre-guide are tested under running conditions at the factory to check the alignment of the spindles and the centre-block in all positions, the spacing of spindle-bores, and the concentricity of the collet seatings. The spindles are made from high-tensile steel, are carried in anti-friction bearings of the pre-loaded type and are fitted with hardened collet seatings. The draw-in collets are fitted with spring compensators to accommodate small variations in bar size and are operated by a toggle mechanism at the end of the work spindles.

When the machine is used for producing large quantities of components which require side-machining operations a spindle-stopping mechanism can be fitted. This comprises a different drum assembly in which each spindle is provided with a multi-plate clutch and brake, controlled by cams mounted around the spindle drum. The clutches and brakes of the spindles are operated during indexing, and the starting and stopping of the spindles is virtually instantaneous. This mechanism, however, is not considered to be suitable for use with heavy-duty forming and drilling operations. All the cross-slides are made from heat-treated steel and are fitted with micrometer dials for final sizing. The forming slides are fitted with adjustable master stops.

The spindle drum, which is indexed by gearing from a Geneva wheel, indexes slightly past its final position and is drawn back by a toggle clamp on to hardened locators and locked in position. The indexing mechanism can be disengaged while setting up to assist in taking a number of trial cuts in any one position. The bar-feed and collet-operating mechanisms, which are readily accessible, are at the front of the machine and the stroke-setting lever for the bar-feed is adjusted along the T-slot of the

cam lever. Both the bar-feed and the collet-operating mechanism can also be disengaged during setting-up. An automatic trip which can be fitted as an extra disengages the feed and operates a signalling lamp when the bar-stock in any one spindle has been consumed. The non-productive movement of drum-indexing the return and approach strokes of the tool slides and the bar-feeding mechanism are accelerated by a quick-operating clutch to reduce the idle time to a minimum. The clutch is engaged through a linkage, which is operated by cam-dogs on the upper wormwheel, to accelerate this part of the cycle and give a constant time of 1·1 seconds. A brake prevents any over-run.

For the production of simple components which can be machined completely in three stations, but owing to their length cannot be produced in tandem by feeding out bar for two or more components with a single bar-feed, a double bar-feeding arrangement can be fitted. The bar-feed, the collet operation, the bar-stops and the cut-off slides are then arranged in stations of six and three, and double automatic trips are fitted. Different lengths of bar may be fed out in the two stations and the second mechanism can be disengaged and the machine used for single-station feeding if required. The speeds and feeds are selected through pick-off gears mounted in a compartment above the driving-motor. The drive is transmitted to a constant-speed shaft by V-belts, and then transmitted by chain drives to the fast-motion clutch, the change gears, and the oil pump.

PETROLEUM STORAGE AND DISTRIBUTION DEPOT.

A PETROLEUM depot from which fuels and lubricants will be distributed to petrol-filling stations and factories within a radius of about 35 miles, has been opened at Westgate Carr-road, Pickering, in North Yorkshire, by Shell-Mex and B.P., Limited, Shell-Mex House, London, W.C.2. This new depot is the first of 15 which are to be built for this company in Great Britain and Northern Ireland. Many of their existing depots are to be enlarged and modernised. With the end of the last war the major oil companies decided to include the United Kingdom in their scheme for setting up new refineries, and more than 125*l.* million has already been spent. The Shell and the Anglo-Iranian companies have together helped in raising Britain's refining capacity from three million tons in 1946 to nearly 28 million tons. Their share in this total is 20 million tons. The refineries receive the crude oil direct from the ocean tankers and distribute refined oils to importing installations around the coast by coastal tankers, from where it is sent by road tankers to the storage depots before finally being sold to the distributor. The refineries and installations will send supplies direct to customers within a radius of 35 miles.

The depot at Pickering covers an area of four acres; it has two vertical tanks each holding 86,000 gallons and 14 horizontal tanks each of 12,000 gallons, giving a total of 340,000 gallons. Each tank is fitted with an external liquid-level gauge in place of a dip-stick type of gauge. The products that will be kept at the depot include various grades of motor spirit, Diesel oil, gas oil, tractor vaporising oil, burning oil, and lubricants. In addition, a small store has been built for barrels of special-grade spirits and lubricants.

The largest building on the site houses the lubricating-oil packaging centre and vehicle service bay. It has a steel portal frame and the roof has been designed to give the maximum amount of natural lighting. Folding doors have been fitted along the whole of the building frontage. The floor of the lubricating-oil centre has been made the same height as the tailboard of the vehicles to assist in loading. The administrative office block which has been built between the entrance and exit to the depot contains the quarters for H.M. Customs and Excise officers, as the depot is a bonded store, as well as those for the staff, supervisor, etc. The full length of two sides of this building have been made of glass to give good interior lighting.

PETROLEUM STORAGE DEPOT.

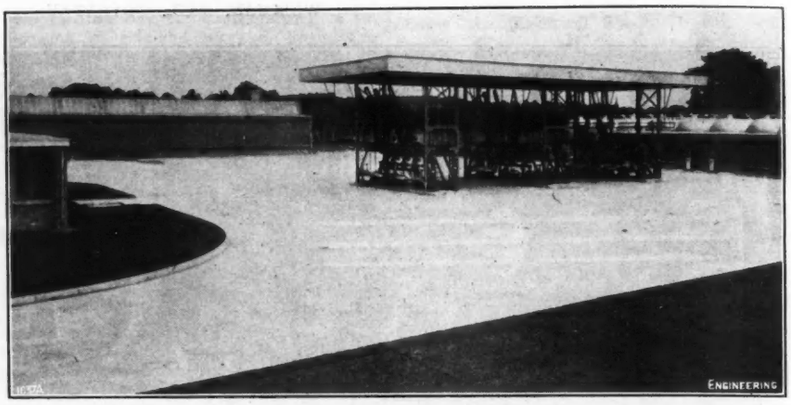


FIG. 1. VIEW OF DEPOT, SHOWING ROAD-VEHICLE FILLING STATION.

FIG. 2. PUMP HOUSE.

Both the buildings are heated from an oil-fired central-heating system, housed below floor level.

In the centre of the yard there is a road-vehicle filling station (Fig. 1). Six lorries can be filled under cover at once, and as the gantry is fed by a separate pump for each product there is no risk of contamination. There are 12 separate outlets, each with a filter, an air separator, a positive displacement meter and a spring-loaded balance arm. As can be seen from the illustration, ample space has been provided for manœuvring the vehicles in the yard and flood-lights are fitted to assist night operation. A two-way loud-speaker system links the offices with the filling gantry, tank compound, and lubricating-oil store. As well as the buildings already mentioned there is the main pump-house shown in Fig. 2. It contains ten motor-driven centrifugal pumps, each capable of delivering 250 gallons a minute. They can be controlled from the filling gantry by push-button switches. A small screw type of displacement stripper pump is also installed for general duties.

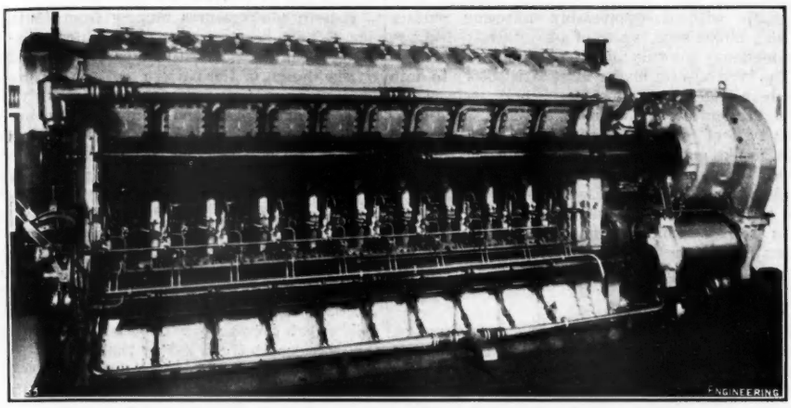
THE LATE MR. P. J. WATTS.—We regret to record the death of Mr. Philip James Watts, which occurred at Tiverton, Devonshire, on Friday, July 31, at the age of 80. On the completion of his technical training he entered the electricity supply industry and subsequently became borough electrical engineer at Whitehaven. He afterwards joined the Admiralty service and was successively assistant electrical engineer at Devonport Dockyard and electrical engineer at Gibraltar. He was appointed an officer of the Order of the British Empire on his retirement some years ago. He joined the Institution of Electrical Engineers as an associate in 1895 and was transferred to the class of member in 1901.

W. E. HIGHFIELD SHIELD COMPETITION, 1952-53.—The W. E. Highfield Shield and Prize of 10 guineas of the Association of Supervisory Electrical Engineers for 1952-53 has been awarded to Mr. D. H. Taylor for his paper on "Industrial Photo-Electric Cells and Amplifiers." A second prize has been awarded to Mr. C. A. Jones for a paper on "Neon Signs—25 Years' Progress," and a third to Mr. S. H. Harding for a paper on "The Electrical Protection of Three-Phase A.C. Motors." Messrs. Taylor and Jones also won prizes last year.

B.E.A. "VISCOUNT" AIR-LINERS IN SERVICE.—In their first 2,000 hours of passenger service, the Viscount 700 air-liners of British European Airways have made an excellent start and have earned a profit of 68,000*l.* The Corporation state that the Viscount is already operating at the lowest cost per ton mile of any passenger aircraft in their fleet, and that it has a load factor of 62 per cent. on total costs. The Viscount fleet has flown 462,000 statute miles, has carried 16,400 passengers, and has operated 1,590,000 ton-miles, at a total cost per capacity ton-mile of 41·8*d.*; the revenue earned per capacity ton-mile is 49·3*d.* The basic annual costs incurred in 2,000 hours amount to 73,000*l.*; the hourly cruising costs are 78*l.* per flying hour; and the take-off and landing costs are 76*l.* per landing. The total cost per flying hour is 190*l.* The average flight distance is 474 statute miles and the average flight time 2 hours 45 minutes.

3,000-H.P. MARINE DIESEL ENGINE.

GÖTAVERKEN A/B, GÖTEBORG, SWEDEN.



LIGHTWEIGHT SUPERCHARGED MARINE DIESEL ENGINE.

Götaverken A/B, Göteborg, Sweden, have recently put into production a 3,000 shaft-horse-power marine Diesel engine of the opposed-piston two-stroke type with a high supercharge. This new engine, illustrated above, is chiefly remarkable for its extremely light weight, which is of the order of 8 tons only, complete with its scavenging and supercharging units and air cooler, so giving a weight per shaft horse-power of 5·89 lb. as against 115-150 lb. per shaft horse-power for marine Diesel engines of comparable output and orthodox design. This saving in weight—and, it follows, of space—makes the engine eminently suitable for fast naval vessels, for which, in fact, it has primarily been designed, but the intention is also to make the engine available for normal merchant ships. It has an overall length of 18 ft. 4½ in., a height of 7 ft. 10½ in., and a width of 3 ft. 5½ in., the width of the bed-plate being only 2 ft. 7½ in.

The light weight of the engine would suggest that it is in the high-speed category, but, on the contrary, the output of 3,000 shaft horse-power is obtained at the comparatively low speed of 975 r.p.m., while the engine is rated continuously with an output of 2,500 shaft horse-power at 920 r.p.m. The engine is arranged vertically with ten cylinders, the opposed pistons driving a crankshaft at the top of the engine, connected by gearing to the second crankshaft in the base, the two crankshafts having the same direction of rotation, with the lower directly connected to the propeller shaft. The cylinder bores are 7·087 in. in diameter and the stroke of each piston is 9·055 in., giving a combined stroke of 18·11 in. for each cylinder, and a total swept volume of 7,138 cub. in. At the maximum rating of 3,000 shaft horse-power the piston speed is 1,472 ft. a minute and the mean effective pressure is 168·3 lb. per square inch.

Scavenging and supercharging are by means of an exhaust-driven turbo-compressor which runs at 16,000 r.p.m. and provides scavenging air at 23 lb. per square inch. When the engine is developing 2,500 shaft horse-power, or more, the power of the turbine is sufficient to drive the compressor and it runs independently of the main engine; for lower outputs, the compressor receives additional power from the upper crankshaft through a gear-train and a free-wheel, or over-running, device. Between the compressor and the engine an air-cooling unit is fitted which brings the temperature of the compressed air down to 105 to 130 deg. F., depending on the degree of engine loading.

As is to be expected in such an engine, there are several features of note in regard to the general design of the whole unit; for instance, the housings of the main bearings of the two crankshafts are tied together with high-tensile steel tubing to take care of the upward and downward thrust of the two opposed pistons, while the main body of the engine is itself a fabricated steel structure. Another feature is the provision of needle bearings to the small-ends, and white-metal bearings for the crankshafts and big-ends; these white-metal bearings, however, are fitted with oil-cooled inserts which limit the bearing temperatures. The pistons are not cooled; they are of a light alloy with tops of heat-resisting steel, which also carry the first two rings on each piston. The gearwheels on the crankshafts are designed as torsional vibration dampers, and in addition a vibration damper is fitted to the upper crankshaft at its forward end; these dampers are said to counteract torsional vibrations so efficiently, when passing through the critical speeds, that no additional stresses above 1,400 lb. per square inch are said to occur.

The fuel consumption at the continuous rating of 2,500 shaft horse-power is 0·385 lb. per shaft horse-power, and the lubricating-oil consumption is 0·09 oz.

THE SHELL MOULDING PROCESS.*

By D. N. BUTTREY, M.Sc., A.R.I.C., A.P.I.

THE first technical details of the shell moulding process, also referred to as the "C" process, based on the interrogation by W. W. McCullogh (of the Technical Industrial Intelligence Division, U.S Dept. of Commerce) of J. Croning in Hamburg, were published as Report No. 1168 of the Office of Technical Services, U.S. Dept. of Commerce, on May 30, 1947. It is reported that a patent application (No. 48679) was filed in the German patent office on February 1, 1944, on the process of making thin moulds and cores with approximately uniform wall thickness, from dry-sand/resin mixtures, also including the use of fillers such as metal powder, metal oxides and graphite. This patent application was kept secret by the German Government, although by June, 1944, the process was in production at several foundries, and, at the firm of Haller Werke A.G., in Hamburg-Altona, the production of cores for 8-cm. hand-grenades by the process had reached a figure of 6,000 components per day.

Since 1947, the development of the shell-moulding process has proceeded more rapidly in the United States than in Great Britain, and it is now being used in a number of foundries, including that of the Ford Motor Company (U.S.A.), where, it is stated, an estimated 150 tons per day of metal is poured into shell moulds to make at least 40,000 exhaust valves daily, and also camshafts, crankshafts and rocker arms. It is estimated that in the new Ford "6," shell-moulded parts comprise approximately 15 per cent. of the total engine weight, and, to date, this company has invested perhaps 8 million dols. in the process. In Great Britain, the process is now in operation in several foundries although as yet on a comparatively limited scale; during the past year however, interest in it has been considerable and development work is now widespread. In Denmark, from December, 1950, to July, 1951, some 6,000 small engine cylinders were produced by the process and, in spite of the experimental nature of the production, the total percentage of waste was below the previous figures relating to oil-sand moulded cylinders.

It is reported that at least six companies in the United States are at work on commercial machines for making shell moulds and their designs are of two general types, i.e., single-station machines, which provide a single pattern with its own oven and multi-station machines carrying from two to a dozen patterns through a common oven. The multi-station machines are designed for mass-production work, one machine producing 1,000 shell moulds per hour on a 12-station turntable. British Patents have been granted relating to apparatus for making casting cores and the production of metal patterns, and apparatus for cooling shell moulds during casting.

Estimates on the future of shell moulding in the United States have been very ambitious; for example, it has been forecast that resin consumption by the process will be nearly 80 million pounds in 1957 (equivalent to over 400,000 tons of sand shells), and that shell moulding will replace half of all sand casting within ten years. Although such phenomenal expansion is certainly not anticipated in Great Britain, nevertheless it would appear only a matter of time before shell-moulding becomes an established part of foundry practice in this country.

The shell-moulding process is essentially a method of manufacture of sand moulds and cores for foundry casting in the form of relatively thin shells of approximately uniform wall thickness. The process of making such shells is one by which a dry powdered sand/resin mixture is brought into contact with a heated metal pattern under such conditions that the required thickness of shell is rapidly formed on the pattern, after which the shell is hardened while still on the pattern, by the application of heat. The hardened shell is then lifted from the pattern. For use as a mould for casting, two such shells are clamped together, cores being inserted where necessary. During casting, the shell moulds may be merely supported by mechanical means to allow the metal to flow correctly through the runners or, alternatively, for certain applications, may be backed with loose granular material.

CHARACTERISTICS OF THE PROCESS.

To assess the value of the shell-moulding process for foundry use, it is necessary to compare it with the other processes at present available for metal casting.

The shell-moulding process is particularly suited to casting thin sections where high definition is required, for example, air-cooled petrol-engine cylinders. The permeability of the mould walls is high in spite of the use of fine sand in making the shells since no ramming or "densification" is employed and it is, therefore, possible to eliminate gassing difficulties in certain types of castings. For ferrous metals, it is possible to obtain as good results as with die-casting methods for non-ferrous metals. Even for non-ferrous metals, shell-moulding is competitive with plaster or die-casting for mass producing smooth castings which require little or no finishing. As an example of the thinness of castings possible by the shell-moulding process lettering in both ferrous and non-ferrous metals has been successfully cast with a cross section as small as $\frac{1}{16}$ in.

At the present time, there are definite limits to the production of larger castings by the process. Unless shell wall thicknesses are used such that the method becomes uneconomical, only a limited weight of molten metal can be supported, although the backing of the shell during casting, and the cooling of such backing, may do much to increase the limits of size of casting possible, and it has been stated that whereas castings of 20 lb. to 30 lb. in weight were considered an upper limit, castings in excess of 200 lb. are in the making.

It must also be realised that pattern design has to be such that shells can be lifted from the pattern after forming and therefore, although inserts may

* Paper presented during the 50th Annual Conference of the Institute of British Foundrymen, held in Blackpool from June 16 to 19, 1953. Abridged.

be placed in the shell moulds that allow undercuts in the final casting, nevertheless, greater intricacy of castings is possible with the lost-wax process. As yet, the possibility of moulds made up from more than two shells does not appear to have received attention.

The shell moulding process gives high surface finish to castings and reduces finishing operations considerably. This is because it is possible to use sand of finer mesh size than can be employed in normal sand-moulding techniques, at the same time achieving equal permeability. The use of a relatively high binder concentration in the sand holds the fine sand together firmly to give a smooth hard casting surface to the mould.

Castings made by shell-moulding are characterised by sharpness of definition and low tolerances, compared with those made by conventional sand-moulding techniques. Tolerances of 0·003 in. per inch are possible and even closer tolerances are claimed. It should be noted that there is an absence of chilling of metal surfaces cast in shell moulds. On the question of tolerances, the problem of the matching up of shells is important and it is obvious that if bowing or distortion of the shell occurs during forming, tolerances will be considerably greater across certain sections of castings. The practice of providing bolt-holes through the shells at a number of points so that the two shell halves may be firmly bolted together will correct minor distortion of shells. If major distortion occurs this can only be corrected by modification to the basic design of the pattern.

Shell moulds can be stored for long periods without apparent deterioration, and the weakening due to moisture absorption or "striking back" observed with many oil- and resin-bound sand cores does not occur in sand shells. Shells that have been stored under normal, dry conditions have shown no visible surface friability after twelve months. The fact that shell moulds can be stored and be immediately available for use at any time is of some importance from the production viewpoint and enables runs of components to be made at short notice.

The economics of the shell-moulding process are difficult to assess, and can be considered only in relation to the specific requirements of individual foundries. The basic cost of the sand/resin mixture suitable for shell-moulding is relatively high, of the order of 20*l.* to 30*l.* per ton. Pattern costs are high. Offsetting these is the fact that for both mould and core work, the quantity of sand used is only a fraction of that used by normal sand-moulding techniques. Handling costs are reduced, also fettling and finishing costs. For core work, the rapid-hardening cycle of shell cores means considerable savings in fuel for a given number of components.

Indirect savings will also result from a reduction of scrap due to gassing and tearing on thin sections of castings. For certain applications, the quality of the castings will justify the higher cost of the mould. Of particular note is the fact that for new production, or where expansion in the foundry is envisaged, both the capital equipment and the foundry space required to introduce shell-moulding for a given volume of work can be considerably less than where conventional sand-moulding techniques are used.

Basic Operation of the Shell-Moulding Process.

The sand required for making sand shells is a fine, dry, silica sand, free from clay and organic impurities, and if necessary sieved to eliminate sea shells and coarse particles. Sand of 100 to 150 mesh B.S. sieves is desirable; particles coarser than approximately 100 mesh give strength to the shell but mar the surface finish and, above 150 mesh, the strength of the shell is decreased without corresponding improvement in the surface finish. Redhill "H" grade silica sand, fine Chelford, and other reasonably pure silica sands have been found satisfactory for the process.

In conventional sand-moulding, the use of additives such as clay, sand, bentonite, coal-dust, etc., to improve specific properties is now established practice. In shell-moulding, the value of ingredients in the mix other than sand and resin binder is still being determined. Plumbago and terra-flake have been proposed to improve the shell surface and increase resistance to metal penetration; inhibitors may be added for light-alloy casting. The incorporation of a certain percentage of coarse-grain sand in the mix will improve shell strength without appreciably affecting surface finish; zircon sand is also of advantage to decrease the tendency towards metal penetration.

The type of resin binder most satisfactory to date has been a so-called two-stage phenolic resin mixed with accelerator, in a finely-powdered condition. This type of resin derives its name from the fact that, unlike many other resins used in the foundry it will only harden when it is heated with the accelerator. Experience has shown that a particle-size of resin somewhat finer than that of the sand gives the best results, too fine a material tending to separate from the sand in the form of dust. This type of resin appears to combine the necessary values for the properties of melting-point, melt viscosity and bonding strength.

For ferrous casting, the following proportions of sand and resin binder are in general satisfactory for shell forming: Dry silica sand, 100 parts by weight and powdered phenolic resin binder, 6 to 8 parts by weight. The actual amounts must depend on the particular sand and resin binder used, and for non-ferrous casting it should be possible in certain designs to reduce the resin content appreciably. It is found that, with a given sand and resin binder, the surface finish of the shell varies little with different resin contents within the range under consideration, but, on the other hand, both the compression and tensile strengths of the shell and the surface friability property depend on the binder content of the mix.

It is essential, during mixing, to ensure that the resin binder is dispersed uniformly throughout the sand; local concentrations of resin in the shell will give resin "spots," which can be responsible for gassing during casting. For mixing, a rotating tumbling-type mixer is preferable to conventional foundry sand mixers, which are liable to deposit unmixed material on the bottom and sides of the mixer and round the blades. Secondly, the powdered resin, which is normally supplied in moisture-proof containers, should not be allowed to stand in contact with the air for undue periods before mixing, since it will exhibit a tendency towards "balling," due to absorption of moisture-vapour from the air. Such "balls" or lumps will normally break down readily on mixing, unless the resin has been too long exposed to the air, when hard lumps, difficult to disperse in the sand, will be formed, giving rise to resin "spots" in the shell. It is wise not to allow the temperature during mixing to rise above 50 deg. C. and hot sand from the dryer must not be used, as is sometimes the practice in normal core-sand mixing. Once mixed, the product will store for reasonable periods in a normal dry atmosphere.

Other ingredients in the mix, such as a wetting agent or a liquid resin, may be added, and it is recommended that they should be first mixed with the sand to wet the surface uniformly, and the powdered resin binder then added.

Without pattern lubricant, the hardened shell will adhere firmly to the pattern and be irremovable without fracture. In general, cast iron has been found the most satisfactory pattern metal, although aluminium and non-ferrous metal alloys and steel have been used. An essential is that the pattern should withstand temperatures of up to approximately 400 deg. C. without melting or warping. Low-expansion metals have obvious advantages in maintaining close tolerances. The possibility of corrosion during the use of aluminium and other non-ferrous alloys must be taken into account.

For lubrication, separating agents based on silicone resins have been found most generally acceptable. In the United States, the literature indicates that there is a preference for emulsions, but comparative tests the author has done suggest that the oils and greases give a more continuous film on the pattern with improved covering power, whereas the emulsions tend to deposit the silicone resin in discrete particles. If the pattern is given two or three pre-treatments with the silicone separating agent, each application being baked on the pattern at 200 to 300 deg. C., then a semi-permanent lubricating surface is built-up, from which a considerable number of shells can be lifted with only occasional lubrication between operations. A more economic separating fluid can be prepared from silicone oils by dilution with solvent.

Pattern temperatures ranging from 150 to 300 deg. C. have been recommended in literature on the process, but actual pattern temperature must depend on the design of the pattern and the type of resin binder used. High pattern-temperatures give faster build-up of the shell and decrease hardening time, although the latter can be controlled by oven temperature. On patterns where design is such that both heavy and light sections are present, the use of high pattern-temperature will give very rapid build-up and hardening on the heavy parts, at the expense of the light sections, during a given investment and oven time, so that there may be a tendency to over-cure the shell on the heavy parts and insufficiently cure the shell on the lighter sections. Alternatively, a low pattern-temperature, combined with a high oven-temperature can cause burning of thin sections protruding from the shell.

In general, a pattern temperature of 200 to 250 deg. C. has been found most useful, with an oven temperature of approximately 300 deg. C. It is found that such a system allows for continuous operation on most types of work, the pattern temperature being maintained reasonably steady during working. For the rapid production of shells, a comparatively low pattern-temperature (200 deg. C.) has been used in combination with a high oven-temperature (400 deg. C.).

When an inverting box is used for shell forming, the investment or build-up time of the shell depends on (*a*) the thickness of shell required, (*b*) the temperature of the pattern, (*c*) the thickness of the pattern. In general, a minimum thickness of pattern desirable is ¼ in., although it must be realised that many sections on the pattern, for example the fins in an air-cooled petrol-engine cylinder or the stem of an engine valve, will be below this thickness.

Where oven heating is used to harden the shell, hardening time depends on (*a*) oven temperature, (*b*) pattern temperature, and (*c*) thickness of shell. At a pattern temperature of 200 deg. to 250 deg. C. and an oven temperature of 300 deg. C., hardening time usually lies between one and four minutes. Higher oven-temperatures, as indicated earlier, will reduce shell hardening time.

(*To be continued.*)

Supplies of Steel Plate for the Shipbuilding Industry.—At a luncheon given in Belfast last week, after the launch of the Rathlin Head, Sir Frederick Rebbeck, the chairman of Harland and Wolff, Ltd., complained that the keel of the next vessel to be constructed in the vacated slipway at the firm's Belfast shipyard could not be laid until January, 1954, owing to the shortage of steel plate. He said that, in spite of statements that the production of steel in Great Britain was increasing, shipbuilders were not receiving any larger quantities than previously. The amount of steel plate allocated to his firm under the new voluntary distribution scheme showed no appreciable increase whatever. The company was also faced with the difficulty of not being able to obtain material in the order in which it was required.

Fellowships of the City and Guilds of London Institute, 1953.—The Council of the City and Guilds of London Institute have conferred the Fellowship of the Institute (F.C.G.I.) upon five past students of the City and Guilds College in recognition of the contribution they have made to the advancement of the industry in which they are engaged. The five new Fellows are Mr. L. P. Coombes, D.F.C., A.C.G.I., B.Sc., F.R.Ae.S., chief superintendent, Aeronautical Research Laboratories, Department of Supply and Development, Commonwealth of Australia; Brigadier L. H. Harris, C.B.E., T.D., A.C.G.I., M.Sc., M.I.E.E., Controller of Research, General Post Office; Mr. R. T. James, O.B.E. A.C.G.I., D.I.C., M.I.C.E., partner in the firm of R. T. James and Partners, consulting civil engineers, Westminster, London, S.W.1; Mr. J. D. Peattie, A.C.G.I., B.Sc., M.I.E.E., deputy chief engineer (generation), British Electricity Authority headquarters; and Sir H. B. Robin Rowell, C.B.E., A.F.C., D.L., M.I.N.A., chairman and managing director, R. and W. Hawthorn, Leslie & Co. Ltd., Hebburn-on-Tyne, and director of National Shipbuilders' Security, Ltd., and the Sunderland and South Shields Water Co.

HIGH-SPEED MILLING AND GREASE-PRODUCING PLANT.

FRYMA MACHINERY COMPANY, LIMITED, GERMANY.

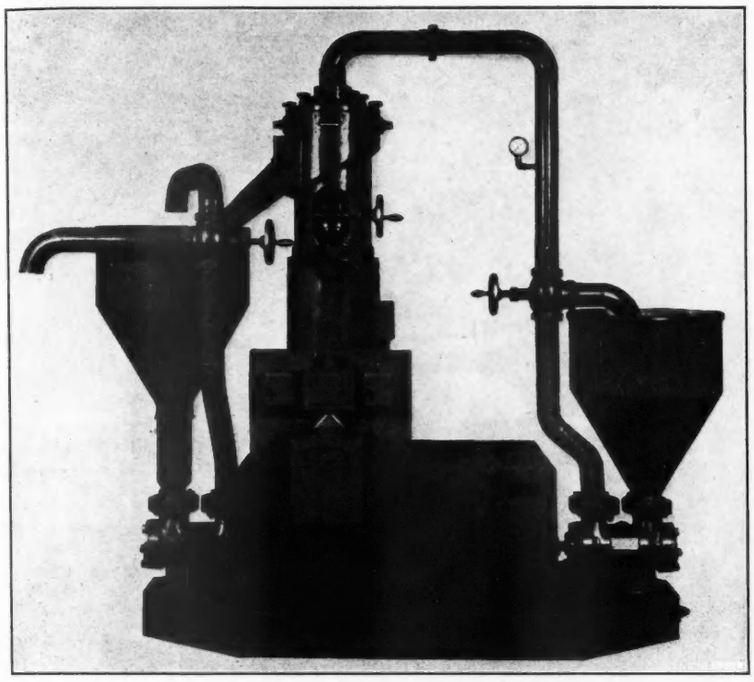


FIG. 1. GREASE-PRODUCING PLANT.

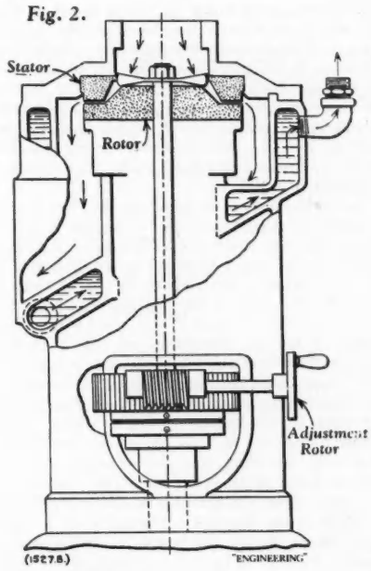
HIGH-SPEED MILLING AND GREASE-PRODUCING PLANT.

A RANGE of high-speed mills and homogenisers which, it is claimed, are capable of much higher rates of production than most contemporary milling equipment, is now available in the United Kingdom. The machines, which are manufactured by the Fryma Machinery Company, Limited, Rheinfelden (Baden), Germany, are distributed by Messrs. Bowser, Monks and Whitehouse, Limited, 45A, Market-place, Doncaster. High-production units suitable for all but the heaviest pastes, small-scale production units, and laboratory mills are available, in addition to a self-contained grease-production plant incorporating a de-aerator and a feed unit.

In principle, as shown in the diagram reproduced in Fig. 2, the Fryma mill, or homogeniser, consists of an accurately-made horizontal circular Carborundum stone, driven by an electric motor, rotating at high speed against a stationary stone, through which the material to be processed is fed. The shearing force between the surfaces of the stones causes a strong splitting and dispersing action. The stationary stone can be manually adjusted in relation to the rotor, to regulate the size of the product, while the machine is in operation. The mechanism is enclosed in a casing of close-grained cast iron in the larger machines, and in cast aluminium in the laboratory unit. If desired, the casings can be supplied with cooling or heating jackets incorporated, and the processing chambers can be of acid-resisting metal. Three types of discharge chute are available on the industrial machines—open, closed, or closed and water-cooled. The laboratory mill has an open chute.

In the Fryma self-contained grease plant, a photograph of which is reproduced in Fig. 1, the homogeniser, which is driven by an 18-h.p., 2,850-r.p.m. motor, is fed from a feed unit comprising a pump driven by a 6-h.p. motor and a feed hopper into which the material can be fed by hand or, if liquid, from a tank. The pump is fitted with a filter to remove impurities. The feed pump delivers the material to the homogeniser at a pressure of 10 lb. to 15 lb. per square inch. The material discharged by the homogeniser is delivered to a hopper feeding a de-aerator unit, which consists of a motor-driven pump and a separator chamber in which is a perforated sheet and a coping ring for regulating the passage of the grease. Four types of perforated sheet and three different coping rings are supplied with the equipment to allow for different consistencies of grease. The pump draws the grease through the separator chamber and delivers it to containers. To give some idea of the output of the plant, the manufacturers have cited the following actual performances: soda-base grease, 7,000 lb. per hour; soda-base grease 180 A.S.T.M. at 185 deg. F., 4,000 lb. per hour; soda-base grease 260 A.S.T.M. at 185 deg. F., 4,300 lb. per hour; aluminium stearate grease No. 2, 2,200 lb. per hour; 9 per cent. bentone grease, 1,100 lb. per hour; lithium grease No. 2, 4,000 lb. per hour.

Fig. 2.



ANNUALS AND REFERENCE BOOKS.

Garcke's Manual of Electricity Supply.

Edited by F. C. GARRETT. Electrical Press, Ltd., 19, Noel-street, London, W.1. [Price 77s. 6d.]

THE nationalisation of the electricity supply of the country has necessitated profound changes in the arrangement of the various directories and handbooks dealing with the industry. These changes have now been completed, so that the 50th edition of "Garcke" follows its immediate predecessors in general arrangement. It begins with a statistical review of progress, based on the reports of the British Electricity Authority, the Area Boards and the North of Scotland Hydro Electric Board. Then follows information regarding certain of the Government Departments connected with the industry as well as of the Area Consultative Councils and various associations and institutions. Very complete details regarding the constitution, powers, finance and organisation of the Central Authority are then given, together with technical data regarding the plant installed in, and the operating results of, the various generating stations. Similar information regarding the activities of the various Area Boards in the United Kingdom, as well as in Ireland, the Isle of Man and the Channel Islands, are also provided, the whole forming a work of reference on the industry the value of which can hardly be exaggerated. Finally, there is a useful trade section and a directory of personnel.

Physique Industrielle.

By JULIEN IZARD. Aide-Mémoire Dunod, Dunod, 92, Rue Bonaparte, Paris, VIe. [Price 480 francs.]

Now in its 29th edition and enlarged to over 500 pages, this volume forms one of a series of handy reference books issued by Messrs. Dunod and contains much practical information of service to industrial physicists and mechanical engineers. Its scope is confined, in the main, to mechanics and heat, though there are sections on lighting and electrical heating. Definitions of mechanical and thermal quantities are given at the outset, together with the units in which they are measured and the physical laws connecting them. After this comes a summary of the properties of gases and vapours with special reference to dry and moist air. Then follow three chapters the first dealing with the processes of evaporation, drying and distillation, the second with heat exchangers, equipment for heating and cooling liquids and gases (including brief references to electrical and infra-red heating), and the third devoted to the combustion of solid and liquid fuels and procedures for its control. Chapters VI and VII are occupied with the flow of fluids, with pumps for handling liquids, ventilating vans and blowers. The next chapter deals with applications of compressed air and the design of refrigerating plant. Steam-raising plant is then considered in detail, though steam and gas turbines are less fully treated; and this is followed by a chapter on the production and properties of industrial gases and liquid fuels. The final chapter has been rewritten to provide up-to-date information on lighting, heating, ventilation and air conditioning. The liberal provision of numerical tables, graphs and alignment charts adds materially to the usefulness of the work.

Cabma Register of British Products and Canadian Distributors.

Kelly's Directories, Limited, 186, Strand, London, W.C.2, and Iliffe and Sons, Limited, Dorset House, Stamford-street, London, S.E.1. [Price 42s.]

THIS is the first edition of a publication which, we believe, may well become a trade link of importance between the United Kingdom and the Dominion of Canada. It is produced, by the publishers named above, for the Canadian Association of British Manufacturers and Agents, for the purpose of providing potential buyers in Canada with a convenient guide to British products and their sources of supply for the Canadian market. With that aim in view, the various sectional introductions, etc., are printed in French as well as English. The main contents comprise a buyers' guide, followed by a section of advertisements, a list of manufacturers and distributors, lists of proprietary names and trade names, and a French glossary. In the buyers' guide—the section to which most inquirers are likely to turn first—the products are listed alphabetically, each heading being followed by the names of makers of the product, and the names (in italics) of the Canadian supplier or agent, if any. Many firms, apparently, are not represented there, so that the *Cabma Register* should be useful also as an indication of possible agencies, as yet unfilled.

SINGLE-DECK HIGH-SPEED TRAMCAR FOR LEEDS.

In contradistinction to the common policy of substituting motor buses for trams in urban transport, the Leeds Corporation have decided to adopt high-speed single-deck tramcars on certain routes and reserved tracks outside the city area. One of the vehicles designed experimentally for this purpose was described on page 124, *ante*, and another, the electrical equipment for which has been constructed by the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17, is illustrated in Fig. 1.

The motive power is provided by four traction motors, two on each bogie, with an individual output of 50 h.p. at 300 volts. Rates of acceleration up to 3 m.p.h. per second are thus obtainable and rheostatic braking rates up to the same value are available. A view of one of the motors on the bogies with the top half of the gear-case removed appears in Fig. 2. These motors, which are axle-suspended, drive through a resilient tube running on roller bearings on the axle, instead of through the more conventional sleeve bearing. This tube is connected to the motor through rubber bushes. Rubber bushes are also used to couple the two-part gearwheels, so that the transmission of shocks from the track to the gear teeth in the rim and thus to the rest of the equipment is considerably reduced. The noise is also lessened. The gears are helical in form, which assists the smooth transmission of power.

The car is equipped with electro-pneumatic control gear all of which, with the exception of the controllers and the main resistor, is housed in a tower on the roof. In operation, current from one of the two master controllers actuates two valves, one of which closes the exhaust of the operating cylinder and the other admits air to it. The piston is thus displaced and the switch closes. When the control coil is de-energised the air is cut off and the cylinder exhaust opened to the atmosphere. The position of the driver's handle controls the rate of acceleration as well as the speed at which the car will run, any changes taking place smoothly and automatically, while if the handle is moved in the opposite direction the rheostatic track brakes are applied. Separate pneumatic braking is also available. A final safeguard is provided by an emergency switch which ensures that full electric braking is automatically applied if the air supply or control battery fails.

BRITISH STANDARD SPECIFICATION.

The following publication of engineering interest has been issued by the British Standards Institution. Copies are available from the Sales Department of the Institution, 2, Park-street, London, W.1, at the price quoted at the end of the text.

Dimensions of Diamond Truing Tools.—A new specification, B.S. No. 2002, covering the dimensions of diamond truing tools, constitutes another in the series of specifications, issued or in preparation, for diamond tools for use in general engineering. The present publication has been prepared to assist in rationalising the very large number of truing-tool sizes now in use in industry. The dimensions and tolerances for diamond truing tools, of the straight, headed and taper-shank types for grinding wheels, are specified. The weight ranges of single diamonds to be used with each type are also specified, and in an appendix guidance is given to users regarding the correct use of the tools. [Price, postage included, 2*s.* 6*d.*]

British Overseas Airways Corporation.—To prepare for the introduction of the Bristol Britannia air-liner into service next year, British Overseas Airways Corporation have set up a Britannia unit, with Captain W. B. Houston as manager. Twenty-six Britannia aircraft are on order, of which ten will have a longer fuselage than the original version. Early deliveries will include machines capable of conversion from the standard 63-seat layout to a tourist version seating 90 to 93 passengers. The Corporation are also negotiating for three Britannia freighters, with an option on two more freighters and five passenger/freighter aircraft. The Corporation are also preparing for the introduction of the Series 2 Comet air-liner; the operations development unit at London Airport is now carrying out engine-handling and performance trials on a modified Comet I air-liner fitted with Rolls-Royce Avon engines. The Corporation have 12 Series 2 Comets on order, with a seating capacity for 44 passengers; the Series I Comet accommodates 36 passengers.

Non-Corrosive Fluorescent Lamp Fitting.—A lighting fitting made wholly of plastics, for use with fluorescent lamps in corrosive and humid atmospheres, is being manufactured by New Era Industries (Tottenham), Ltd., 1a, Stoneleigh-road, London, N.17. It is made of polyvinyl chloride and is of light weight, another feature being that the spine which incorporates the control gear and reflector is produced as one jointless moulding. It is made in 4-ft. and 5-ft. lengths to accommodate either one or two 40-watt or 80-watt lamps.

SINGLE-DECK HIGH-SPEED TRAMCAR.

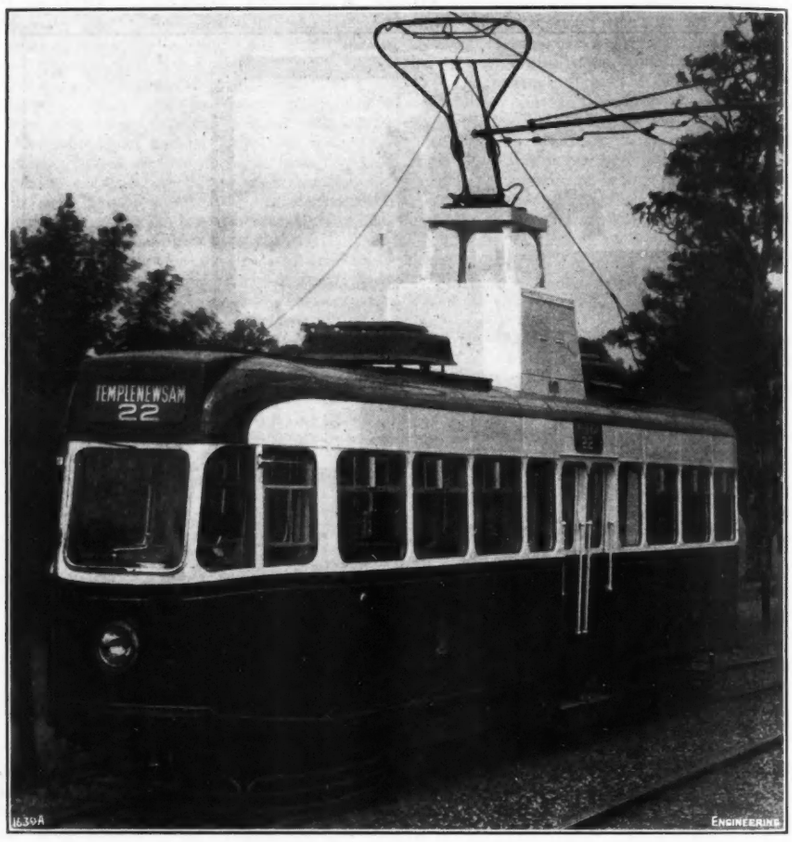


Fig. 1. General View of Car.

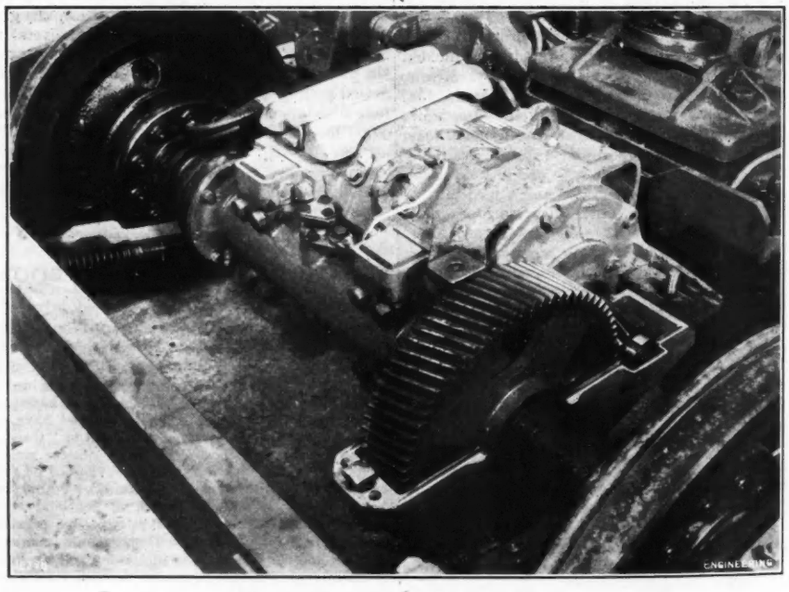
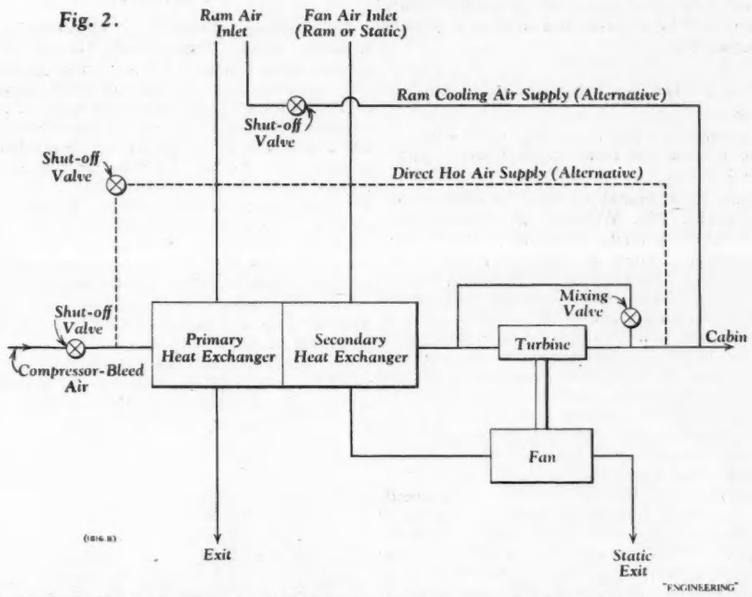


Fig. 2. Traction Motor on Bogie.

COLD-AIR UNIT FOR AIRCRAFT CABINS.

FIG. 1.

Fig. 2.



COLD-AIR UNIT FOR AIRCRAFT CABINS.

THE Hamilton Standard aircraft-cabin refrigerating unit is to be manufactured in the United Kingdom, under licence from the United Aircraft Corporation, East Hartford, Connecticut, U.S.A., by de Havilland Propellers, Limited, Hatfield, Hertfordshire. Production facilities are being installed at their Lostock factory near Bolton, Lancashire, and meanwhile a number of units are being constructed at Hatfield for installation in certain prototype aircraft. Two basic types of cold-air unit are to be made, one for large aircraft and one for fighters.

Fig. 1 shows the unit, which consists of an expansion turbine and a fan mounted on a common shaft, a turbine stator assembly, and a fan assembly. The method of operation may be understood by referring to the diagram reproduced in Fig. 2, which shows a typical fighter air-conditioning installation. The pressurised cabin air, bled from the compressor of the turbine engine, passes through two heat exchangers before entering the cold-air unit. The primary heat exchanger is cooled by ram air from the main engine air intake, and the second heat exchanger is fan-cooled, the cooling air being drawn from any suitable source, by the turbine-driven fan of the cold-air unit. The cabin air, now partly cooled, is led to the intake of the turbine stator assembly; a thermostatically-controlled bypass valve between the outlet of the secondary heat exchanger and the turbine entry allows part of the cabin air to bypass the cold-air unit in order to regulate the temperature of the air entering the cabin.

Air entering the turbine stator assembly is directed through guide vanes to the turbine, where it is expanded and cooled in driving the turbine at a speed of approximately 60,000 r.p.m. The mechanical energy imparted to the turbine is dissipated by the fan, which draws cooling air through the secondary heat exchanger. In a typical high-speed aircraft installation, the air leaving the jet-engine compressor may have a temperature of approximately 328 deg. C. and a pressure of 107 lb. per square inch absolute. On passing through the primary heat exchanger, which is cooled by ram air at a temperature of about 93 deg. C. and 23 lb. per square inch absolute, the cabin air is cooled to approximately 124 deg. C. with only a slight pressure drop to 106 lb. per square inch absolute. It then passes through the fan-cooled heat exchanger where it is cooled to about 102 deg. C. On expansion through the turbine of the cold-air unit, the temperature of the cabin air is reduced to 0 deg. C. and its pressure to about 18 lb. per square inch.

The turbine stator assembly consists of two principal parts, one of which forms the air intake to the turbine rotor and the outlet scroll from the rotor; the other part comprises the nozzle guide vanes for directing the air through the turbine blades. The fan housing assembly provides the air intake to the fan and the outlet scroll which ducts the fan discharge to atmosphere. A central fixture provides a means for aligning the turbine and fan housings and for holding the rotor and fan assembly in position. In order to minimise the thrust loading on the bearings of the rotor assembly, the thrust loads are arranged so that they tend to cancel each other. Allowance for bearing wear and end play caused by thermal expansion of the shaft and casing is made by spring-loading the outer bearing races.

The method of lubricating the bearings is interesting. A grease cartridge, with a life of about 250 hours, inserted in the rotor assembly housing, contains a wick terminating in a felt pad. A small increase in bearing temperature causes oil to separate from the grease and to pass through the pad, then by way of short drilled passages to the bearings. When the unit stops running and cools down, the oil flow ceases. Thus, no excess of oil is discharged as waste nor can it enter the ventilating duct to be carried to the cabin in the form of an oily mist when next the unit comes into action. This method of lubrication also prevents dirt or water from reaching the high-speed finely balanced ball bearings or from obstructing the lubricating passages, as can happen when replenishing conventional oil systems.

NOTES ON NEW BOOKS.

The Induction Motor. The Theory, Design and Application of Alternating-Current Machines, including Fractional Horse-Power Motors.

By HERBERT VICKERS, Ph.D., M.Eng., A.Inst.P., M.I.E.E., F.A.I.E.E. Second edition. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2 [Price 70s.]

THERE are many books bearing titles not greatly different from the above. Some are of a comparatively elementary, or sketchy, nature; others specialise on some specific branch of the subject, such as control. This work, which first appeared in 1924, is a complete treatment of every aspect of induction-motor design. It may be suggested, however, that the word "application" is hardly justified in the position it occupies in the title. The matter is not neglected and there is, for instance, a section on speed control which deals specifically with haulage and rolling-mill motors, while the particular application of the various types of fractional horse-power motors is mentioned, but the applications of the induction motor are so multifarious that they would require a complete volume for their enumeration. This is a small matter, however; the rest of the title is fully justified and the book contains an authoritative treatment of every aspect of induction motor design, theoretical principles, which are fully dealt with, being related to the problems of practice. Speed control, the treatment of noise, testing and other matters of practical importance, are covered, and later chapters deal in detail with the design of slip-ring, squirrel-cage and other types of motor. This edition is a revised version of the earlier one, which has been rewritten to a considerable extent. It contains 531 pages, is fully and well illustrated and is clearly printed on good paper; but the price seems rather high—in fact, it is doubtful if many of the students, to whom Dr. Vickers refers in his preface, will be able to afford it. Designers, however, will find it well worth the money.

Physical Formulae.

By DR. T. S. E. THOMAS. Methuen and Company, Limited, 36, Essex-street, London, W.C.2. [Price 8s. 6d.]

THOUGH formulae in constant use are easily remembered, those only occasionally required are less readily recalled; but, whereas several useful collections of mathematical formulae are available, collections of physical formulae are much scarcer. The contents of this latest Methuen Monograph are divided between 13 pages of mathematical and statistical formulae and just over 100 pages covering the principal laws and relations encountered in the various subdivisions of classical physics. The chapter headings, corresponding to the subdivisions adopted, are Mechanics, Hydraulics, Elasticity, General Physics, Acoustics, Fourier Series, Heat, Light, Electricity and Magnetism, and Electronic Physics. Elasticity is quite fully treated, with sections on springs and on the Hertz theory of contact stresses. Information relating to crystallography and the packing of spheres is included under General Physics, while details of magnetic screening and images, filter circuits, wave guides and cavity resonators appear under Electricity and Magnetism. The dimensional analysis of wave resistance, of resistance to motion in a viscous fluid and of heat transfer are also likely to prove useful. Purely empirical formulae have been omitted, and relatively few references are given, mostly to recently published works. The definition of logarithmic decrement, on page 21, is certainly not the customary one, and an, on page 54, should read a_n. The principal planes of an optical system are more precisely defined as planes of unit positive magnification; the candela now replaces the candle as the unit of luminous intensity; and "luminance"

is now preferred to "brightness" (page 78). Dr. Thomas has used the space at his disposal in a manner calculated to meet with general approval, and has provided a really handy reference book for students and workers in physics and engineering.

The Time for Decision; An Industrialist Looks at Life.

By FRANCIS B. WILLMOTT. The Saint Catherine Press, Limited, 39, Parker-street, London, W.C.2. [Price 15s. net.]

THIS book is a frontal attack on socialism and all its works. Mr. Willmott is a Birmingham industrialist and it would appear that, in the factory or organisation which he operates, a system of what he terms "human relationship" is practised. In brief, this means that friendliness and understanding between the workpeople and management have been established, so that the former feel that they are partners in an enterprise and do not merely regard the firm as an organisation for the production of weekly pay packets. The "fatherly" relationship between master and man has been developed to the extent that loans, without payment of interest, are made to workpeople for the purchase of houses. The expression "it would appear" is used above as this book is not directly concerned with the author's managerial methods; they have been described in an earlier work, bearing the title *The Human Touch in Industry*. As far as it is possible to describe the present book in brief terms, it may be said to be a review and criticism of all the influences and practices which hamper the establishment of a works atmosphere in which operatives will give of their best. The trade unions, in particular, are looked upon as a major influence. Originally established to look after the interests of tradesmen, by their ever-closer association with the Labour Party and their adoption of socialistic practices they are acting to a considerable extent against the interests of their individual members; for instance, by attempting to control the activities of employers, so hampering progress and the establishment of the efficiency in production which is necessary if this country is ever to emerge from its present financial difficulties. Mr. Willmott's survey ranges widely; the dangers and weakness of the welfare state are dealt with, and even such topics as the Education Act, town planning and university graduates in industry are touched on in as far as they bear on the main thesis, which is that national prosperity can only be achieved by the establishment of a works atmosphere very different from that which is now too common.

The Slide Rule

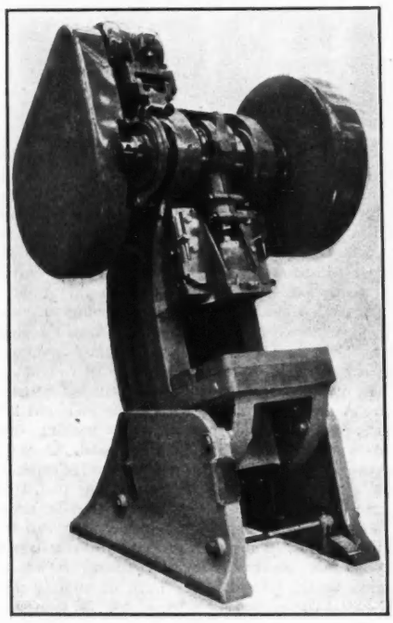
By PROFESSOR J. E. THOMPSON. Second edition, revised and enlarged. Macmillan and Company, Limited, St. Martin's-street, London, W.C.2. [Price 15s. net.]

THIS book is designed to meet the needs of students and to instruct them in the principles of operation of all types of slide rule. The various operations, from division and multiplication to the more difficult solution of expotentials and trigonometric functions, are explained in simple language. Despite the enormous selection of examples presented in the book, however, it seems doubtful whether the student would not do better to ask an experienced colleague to give him a few minutes friendly instruction; such practical tuition can be of far greater value than the most detailed directions in a manual. Nevertheless, Chapter 1 of the book is of some educative value, for it is a brief history of the slide rule, following the invention of logarithms by Napier in 1594 (although his work was not published for another 20 years). In 1620, Edmund Gunter was the first to construct a logarithmic scale along the edge of a strip of wood; within a matter of years the Rev. William Oughtred had laid two such scales side by side to produce the first slide rule in the form that is now familiar. The same reverend gentleman also invented the circular watch-type rule, but for the name of the inspired inventor who first coiled an extra long scale round a cylinder, the curious reader must go elsewhere than Professor Thompson's book.

GEARED INCLINABLE PRESS.

LAST autumn, Messrs. F. J. Edwards, Limited, Edwards House, Euston-road, London, N.W.1, introduced the "Besco" BA Mark 2 range of inclinable power presses, with an adjustable stroke, for capacities from 10, 18, 28 and 40 tons. A geared version of the largest size has now been announced and is shown in the accompanying illustration. It is driven by a 5-h.p. 1,440 r.p.m. motor and is known as the Model BAG 21 Mark 2. Although the press has the same maximum pressure rating of 40 tons as that of the ungeared model, a considerable increase in the working capacity per stroke has been achieved at a reduced speed of 45 strokes per minute, as compared with the 100 strokes per minute necessary on the ungeared model. The flywheel speed has been increased from 100 r.p.m. to 230 r.p.m.

The length of the stroke is adjustable from $\frac{1}{2}$ in. to $3\frac{1}{4}$ in., which $\frac{1}{8}$ in. more than the adjustment and maximum stroke of the ungeared model. The adjustment is made at the eccentric bush



fitted to the split-sleeve pitman. This bush carries a flange engraved with the stroke lengths and it is simply turned to the required figure and secured by a locknut. The connection between the pitman and the ram consists of a ball-end screw and a locknut. The screw, which is of high-carbon steel, heat-treated and machined with a buttress thread, is provided with an adjustment of $2\frac{1}{2}$ in. for tool-setting. The maximum clearance between the ram and the bed, at the bottom of the stroke and with the ram adjustment up, is 11 in.

The press is of light but rigid construction. The frame is of cast iron and is fitted with a plain bolster. The crankshaft is machined from a nickel-chromium-molybdenum forging and heat-treated, and is supported in long phosphor-bronze bearings. The spurwheel is mounted at the clutch end. A spring-adjusted friction-damper prevents overrunning and a safety pawl prevents reverse rotation. The clutch, of the roller-key type, is treadle-operated and engages in a hardened seat in the flywheel hubs. It may be set for either non-repeat or continuous operation, and has a safety-locking device for use while tool-setting. The ram is carried in long V-guides, and can be adjusted to take up wear in the slideways. A bar-type knock-out is fitted. The gears are machine-cut and are completely covered by guards.

The machine can be supplied with the motor mounted on an adjustable plate on top of the machine and with the V-rope drive completely guarded; or, alternatively, with a belt-drive. The lubrication system which can be fitted if required is of the hand-operated type. It is mounted at the rear of the press and employs a one-shot type of pump, connected by tubing to the big-end bearing, the crankshaft main bearings and the slideways. The illustration shows how the press can be inclined to allow work to fall through the back of the press on to a conveyor, or into a truck. The adjusting nut for tilting the press operates on a long screw in the slot which can be seen in the sides of the base.

The press weighs not quite 3 tons, stands $7\frac{1}{4}$ ft. high, and occupies a floor space of 48 in. by 53 in. The dimension from the centre to the back of the press is $8\frac{1}{2}$ in.; from the bed to the guide plates 15 in., and the opening through the back is $13\frac{1}{2}$ in. The size of the bed from left to right and front to back is $23\frac{3}{4}$ in. by $16\frac{3}{4}$ in. The hole in the bed is $11\frac{1}{2}$ in. by $9\frac{1}{2}$ in., and from the ram face over the V-slides from left to right and from front to back is 12 in. by $8\frac{1}{2}$ in. The hole in the ram is 2 in. in diameter. The electrical equipment fitted is normally for a 400/440-volt three-phase 50-cycle supply and has a push-button starter.

BOOKS RECEIVED.

Fundamental Processes of Electrical Contact Phenomena. By DR. F. LLEWELLYN JONES. Radio Research Special Report No. 24. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 3s. net.]

Colliery Year Book and Coal Trades Directory, 1953, The Louis Cassier Company, Limited, Dorset House, Stamford-street, London, S.E.1. [Price 30s. net.]

Instrument Technology. Vol. I. Measurement of Pressure, Level, Flow and Temperature. By E. B. JONES. Butterworth's Scientific Publications, 88, Kingsway, London, W.C.2. [Price 35s. net.]

Annual Report of the Trustees of the Museum of Applied Arts and Sciences, Sydney, 1952. Director of the Museum of Applied Arts and Sciences, Sydney, New South Wales, Australia.

Diamond Pyramidal Hardness Testing of Spherical Specimens. With Special Reference to the Calculation of Indentation Area. By J. A. MACINANTE and N. J. C. PERES. Division of Metrology Technical Paper No. 1. Commonwealth Scientific and Industrial Research Organisation, Melbourne, Australia.

Aluminium and its Alloys in Building. An Introductory Survey. Aluminium Development Association, 33, Grosvenor-street, London, W.1. [Price 3s. 6d.]

Copper in Instrumentation. Copper Development Association, Kendals Hall, Radlett, Hertfordshire. [Gratis.]

Gas Turbine Analysis and Practice. By PROFESSORS BURGESS H. JENNINGS and WILLARD L. ROGERS. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 36, U.S.A. [Price 8.50 dols.]; and McGraw-Hill Publishing Company, Limited, 95, Farrington-street, London, E.C.4. [Price 68s.]

The Railway Fuel and Traveling Engineers' Association. Sixteenth Annual Proceedings 1952. Offices of the Association, Room 1213, 139 W. van Buren-street, Chicago 5, Illinois, U.S.A.

Materials Handling Equipment and Methods in the U.S.A. Organisation for European Economic Co-operation, 2, Rue Andre Pascal, Paris (16e). [Price 9s., or 450 francs.]

Eighty-Ninth Annual Report on Alkali &c. Works by the Chief Inspectors 1952. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2s. 6d. net.]

United States National Bureau of Standards. Circular No. 529. *Electrodeposition Research.* Proceedings of the Semicentennial Symposium held at the N.B.S. on December 4-6, 1951. The Superintendent of Documents. U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 1.50 dols.]

Garcke's Manual, 1952-1953. A Statistical Record of the British Electricity and Allied Manufacturing Industries, including a Directory of Executive Personnel. Compiled under the direction of FREDERICK C. GARRETT. Electrical Press Limited, 19-20, Noel-street, London, W.1. [Price 77s. 6d. post free.]

Mitteilungen aus dem Institut für Thermodynamik und Verbrennungsmotorenbau an der eidgenössischen technischen Hochschule in Zürich. No. 12. *Druckwellen-Spülung bei Zweitaktmotoren (Berechnung und Versuche).* By DR. YIAN-NIAN CHEN. Verlag Leemann, Stockerstrasse 64, Zürich, Switzerland. [Price 10·40 Swiss francs.]

Report of the Mechanical Engineering Research Board, with the Report of the Director of Mechanical Engineering Research, for the Year 1952. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2s. 6d. net.]

Trade Unions Today. Substance of three talks delivered to the British Institute of Management by SIR VINCENT TEWSON, MR. TOM WILLIAMSON, and MR. J. A. BIRCH. Offices of the Institute, Management House, Hill-street, London, W.1. [Price 1s. 3d.]